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Segment 1A – RFU Walls Package 2 Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and Embankment EMB: I-405 SB MP 5.97 to 5.83

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WSDOT I-405 Renton to Bellevue Design-Build

Renton to Bellevue, Washington

Project # PS19-20316-0

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List of acronyms

AASHTO	American Association of State Highway and Transportation Officials
A_S	Site Class-Adjusted Peak Ground Acceleration
ASTM	American Society of Testing and Materials
BDM	Bridge Design Manual
bgs	Below Ground Surface
CALTRANS	California Department of Transportation
CIP	Cast-In-Place
COV	Coefficient of Variation
Cu	Coefficient of Uniformity
EPS	Expanded Polystyrene
ESU	Engineering Stratigraphic Unit
FHWA	Federal Highway Administration
F*	Pullout Resistance Factor
FS	Factor of Safety
GBR	Geotechnical Baseline Report
GDM	Geotechnical Design Manual
GDR	Geotechnical Data Report
GLE	Generalized Limit Equilibrium
HRM	Highway Runoff Manual
H:V	Horizontal:Vertical
I-405	Interstate 405
ka	Active Earth Pressure Coefficient
kae	Static + Seismic Earth Pressure Coefficient
kh	Horizontal Seismic Acceleration Coefficient
ksf	Kips Per Square Foot
LRFD	Load and Resistance Factor Design
MADTL	Minimum Allowable Distance to the Travel Lane
M-O	Mononobe-Okabe
MOT	Maintenance of Traffic
MP	Milepost
$N1_{60}$	Field Blow Count Corrected for Overburden Pressure and Hammer Efficiency
$N1_{60}(cs)$	Equivalent Clean Sand Corrected Field Blow Count
NAVD 88	North American Vertical Datum of 1988

NCHRP	National Cooperative Highway Research Program
pcf	Pounds Per Cubic Foot
PGA	Peak Ground Acceleration
Project GDM	Project Geotechnical Design Manual, consisting of WSDOT's 2015 *Geotechnical Design Manual*, along with project-specific Chapters 6 (Seismic) and 15 (Retaining Walls) from Request for Proposal Addendum 9
psf	Pounds Per Square Foot
psi	Pounds Per Square Inch
RECO	Reinforced Earth Company
RFU	Released for Use
RFP	Request for Proposal
SEE	Safety Evaluation Earthquake
SEW	Structural Earth Wall
SPT	Standard Penetration Test
Sta.	Station
USCS	Unified Soil Classification System
USGS	United States Geological Survey
WADNR	Washington State Department of Natural Resources
Wood	Wood Environment & Infrastructure Solutions, Inc.
WSDOT	Washington State Department of Transportation

1.0 Introduction

This geotechnical engineering report provides conclusions and recommendations to facilitate final design and construction of proposed Grade Separation Barrier 05.33R; retaining Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83. The referenced barrier, walls, and embankment are part of Segment 1A of the Interstate 405 (I-405) Renton to Bellevue Widening and Express Toll Lanes project. A Vicinity Map of Segment 1A is included as Figure 1.

Locations of the proposed barrier, walls, and embankment addressed in this geotechnical engineering report are presented on Retaining Wall Plan Figures 2S, 2T, and 2U. Barrier, wall, and embankment profiles and design sections are presented in Appendices C through G.

This geotechnical engineering report has been prepared in accordance with the requirements presented in the I-405 Renton to Bellevue Widening Project conformed Request for Proposal (RFP), specifically Section 2.6.5.3, and the applicable sections of the Washington State Department of Transportation (WSDOT) Geotechnical Design Manual (GDM) M 46-03.11 including the project-specific revised GDM Chapters 6 and 15 provided in the conformed RFP (Project GDM).

2.0 Description of Barrier, Walls, and Embankment

Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 are addressed in this geotechnical engineering report. The barrier, walls, and embankment are described below. Table 1 presents a summary of the barrier, wall, and embankment sections considered in design.

Grade Separation Barrier 05.33R: Grade Separation Barrier 05.33R is a rigid, concrete barrier located on the east side of northbound I-405, west of the North Southport Drive on-ramp. It is approximately 100 feet in length and 4 feet tall at its maximum exposed height. It is our understanding that the back of the barrier will be battered at 4H:21V (horizontal to vertical) (10.8 degrees from vertical). The critical design section was selected based on maximum barrier height.

Grade Separation Barrier 05.33R will be designed in accordance with WSDOT Bridge Design Manual (BDM) Section 10.3.1 for differential grade concrete barriers. Design calculations for Grade Separation Barrier 05.33R will be submitted under separate cover by the design-build team's wall designers.

Wall 05.55L: Wall 05.55L is a cast-in-place (CIP) concrete retaining wall located on the west side of the southbound I-405 off-ramp to Southport Drive. It is approximately 130 feet in length and 4.5 feet tall at its maximum exposed height. The critical design section was selected based on maximum wall height.

Walls 05.85L-A and 05.85L-B: Walls 05.85L-A and 05.85L-B are Structural Earth Walls (SEWs) located on the west side of southbound I-405, north of the North Southport Drive off-ramp. Wall 05.85L-A is approximately 100 feet in length and about 17 feet tall at its maximum exposed height. Wall 05.85L-B is approximately 335 feet in length and about 20 feet tall at its maximum exposed height. Walls 05.85L-A and 05.85L-B will be designed with consideration of forward compatible loading for future widening of I-405. The critical design sections for these walls were selected based on maximum wall height. Based on wall/slope geometry and maintenance of traffic (MOT) requirements, temporary shoring will be required to facilitate construction of Walls 05.85L-A and 05.85L-B.

Embankment EMB: I-405 SB MP 5.97 to 5.83: Embankment EMB: I-405 SB MP 5.97 to 5.83 is located on the west side of southbound I-405 between Walls 05.85L-A and 05.85L-B. EMB: I-405 SB MP 5.97 to 5.83 is a widening of the existing embankment and will be constructed with 2H:1V side slopes. As noted in the reference report in the RFP "General Geologic Characterization and Unstable Slope Evaluation" dated December 14, 2018, a fill slope failure (SB2: SB I-405 MP 5.90 – 5.94) occurred at the location of proposed EMB: I-405 SB MP 5.97 to 5.83 during the I-405 widening in 1985. The slope failure was mitigated by construction of a rock buttress and toe drainage system that will remain in-place for the proposed embankment construction. The critical design section was selected near the midpoint of the embankment.

Table 1: Summary of Critical Design Sections by Barrier/Wall/Embankment

Design Element	Cut/Fill	Design Section Stations/ Mileposts	Maximum Exposed Height (feet)	Minimum Reinforcement Length (feet)	Foreslope (degrees)	Backslope (degrees)	Wall Type
Grade Separation Barrier 05.33R	Fill	Sta. 1+58	4.0	NA	0	17.5	NA
Wall 05.55L	Fill	Sta. 1+50	4.5	NA	15	0	Cast-In-Place
Wall 05.85L-A	Fill	Sta. 1+90	16.7	15.5[1] (upper 6 rows) 20[2] (bottom 2 rows)	27	27	Structural Earth Wall
Wall 05.85L-B	Fill	Sta. 2+60	19.6	16.5[3]	15	27	Structural Earth Wall
Embankment EMB: I-405 SB MP 5.97 to 5.83	Fill	MP 5.88	NA	NA	NA	NA	NA

Notes:
1. To satisfy minimum global and compound stability requirements, the reinforcement length is approximately 0.8 times the height of the wall (exposed height plus embedment depth).
2. To satisfy minimum compound stability requirements, the reinforcement length is approximately 1.0 times the height of the wall (exposed height plus embedment depth).
3. Reinforcement length is approximately 0.7 times the height of the wall (exposed height plus embedment depth).

Abbreviations:
MP = Mile Post
NA = Not Applicable
Sta. = Station

3.0 Surface Conditions

Grade Separation Barrier 05.33R: The existing ground surface at Grade Separation Barrier 05.33R is a vegetated slope with grass and some small trees.

Wall 05.55L: The existing ground surface at Wall 05.55L is a relatively steep slope covered with mature trees and grasses.

Wall 05.85L-A: The existing ground surface at Wall 05.85L-A is a relatively steep slope covered with mature trees and grasses.

Wall 05.85L-B: The existing ground surface at Wall 05.85L-B is a relatively steep slope covered with trees and grasses.

Embankment EMB: I-405 SB MP 5.97 to 5.83: The existing ground surface at embankment EMB: I-405 SB MP 5.97 to 5.83 is a steep slope covered with mature trees and grasses. Quarry spalls are placed at the toe of the slope as a rock buttress installed as part of the 1985 fill landslide repair.

4.0 Explorations and Laboratory Testing

4.1 Conformed RFP Explorations and Laboratory Testing

We reviewed previous subsurface explorations and laboratory test results provided in the RFP Geotechnical Data Report (GDR). Information reviewed included historic data from previous studies along the project alignment and project-specific data from explorations completed prior to preparation of the RFP (RFP explorations). Exploration logs and laboratory test results

used for soil property and subsurface profile development are reproduced in Appendices A and B, respectively. The historic and RFP exploration locations are shown on Retaining Wall Plan Figures 2S, 2T, and 2U.

4.2 Explorations Completed by Design-Build Team

To supplement the information provided in the project GDR, subsurface explorations were completed by the design-build team in compliance with the exploration location, spacing, and depth requirements per Project GDM Section 15-3.4 for the walls and barrier, and per Project GDM Section 9.1 for the embankment. The supplemental (Post-RFP) explorations consisted of four borings, W-207-20, W-215-20, W-217-20, and W-218-20, drilled between July and August 2020 near the proposed locations for Grade Separation Barrier 05.33R, and Walls 05.55L, 05.85L-A, and 05.85L-B, respectively. At Grade Separation Barrier 05.33R and Wall 05.55L, historical and RFP borings were not located within the contractual baseline boundary for retaining walls outlined in the RFP Geotechnical Baseline Report (GBR); therefore, to characterize subsurface conditions, boring W-207-20 was drilled near the face of Grade Separation Barrier 05.33R, at approximately the center of the alignment, and boring W-215-20 was drilled upslope of Wall 05.55L, approximately 23 feet east of the center of the alignment. Boring W-217-20 was drilled upslope of Wall 05.85L-A to confirm subsurface conditions behind the south end of the wall. Boring W-218-20 was drilled upslope of Wall 05.85L-B to confirm subsurface conditions behind the north end of the wall.

RFP borings R2B-10-17 and R2B-11-17 were drilled approximately 13 and 28 feet east of the centerline of the Wall 05.85L-B alignment, respectively, which confirmed subsurface conditions near the wall face.

We used both historical borings H-1-85 and H-2-85 to develop the soil properties at Wall 05.85L-A and embankment EMB: I-405 SB MP 5.97 to 5.83, however, these borings align at approximately the same location when projected onto the respective wall and embankment design sections. We used boring H-1-85, which is located within the embankment, to define the subsurface at the embankment, and we used boring H-2-85, which is located below Wall 05.85L-A, to define the subsurface at Wall 058.85L-A.

A summary of the historical, RFP, and Post-RFP explorations at the barrier, wall, and embankment locations is presented in Table 2.

Table 2: Summary of Explorations by Barrier/Wall/Embankment

Design Element	Nearby Explorations (Total Explorations)	Maximum Boring Spacing (feet)	Project GDM Exploration Compliance Requirements	Notes
Grade Separation Barrier 05.33R	W-207-20 (1)	Not Applicable	Meets exploration requirements for walls under 10 feet in height per Project GDM Section 15-3.4	Exploration compliance requirements for retaining walls were applied to Grade Separation Barriers
Wall 05.55L	W-215-20 (1)	Not Applicable	Meets exploration requirements for walls under 10 feet in height per Project GDM Section 15-3.4	-
Wall 05.85L-A	W-217-20, H-1-85, H-2-85, H-3-85 (4)	95	Meets exploration requirements for walls greater than 100 feet in length per Project GDM Section 15-3.4	-

Design Element	Nearby Explorations (Total Explorations)	Maximum Boring Spacing (feet)	Project GDM Exploration Compliance Requirements	Notes
Wall 05.85L-B	W-218-20, R2B-10-17, R2B-11-17 (3)	170	Meets exploration requirements for walls greater than 100 feet in length per Project GDM Section 15-3.4	-
Embankment EMB: I-405 SB MP 5.97 to 5.83	W-217-20, H-1-85, H-2-85, H-3-85 (4)	Not Applicable	Meets exploration requirements for embankments per Project GDM Section 9.1	-

Post-RFP explorations and accompanying Post-RFP laboratory test results used for soil property and subsurface profile development are reproduced in Appendices A and B, respectively. The Post-RFP exploration locations are shown on Retaining Wall Plan Figures 2S, 2T, and 2U.

5.0 Subsurface Conditions

5.1 Regional Geology

Geologic maps available through the Washington State Department of Natural Resources (WADNR) indicate that the surficial soils in the vicinity of Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 include Pleistocene continental glacial drift (Qpa) and continental glacial till (Qgt). Glacial drift and glacial till are both glacially derived and typically glacially overridden, resulting in a very compact nature. Particle size distribution typically includes sandy silt, silty sand, and sand with silt, all with variable gravel content. Cobbles and boulders are also commonly present. These units are typically dense to very dense.

5.2 Engineering Stratigraphic Units

Based on our review of subsurface explorations and accompanying laboratory test results, we have defined engineering stratigraphic units (ESUs) for use in design along the Segment 1A alignment. ESUs were subdivided to account for variations in soil density/consistency and dominant grain size. ESUs defined for design of Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 are summarized below. Subsurface conditions showing the distribution of ESUs are provided on the profiles and design sections presented in Appendices C through G.

- **ESU 1 – Existing Fill**
    - **ESU 1A – Loose to Medium Dense Coarse-Grained Fill**: This ESU consists of existing fill, typically very loose to loose silty sand and sand with varying amounts of silt, gravel, cobbles, and wood. ESU 1A was encountered directly below the ground surface in borings H-1-85, H-2-85, and H-3-85 near Wall 05.85L-A and embankment EMB: I-405 SB MP 5.97 to 5.83. The elevation range at which ESU 1A was observed is above the existing ground surface at Wall 05.85L-A; therefore, ESU 1A is not expected to be encountered during construction of the wall.
    - **ESU 1B – Medium Dense to Very Dense Coarse-Grained Fill**: This ESU consists of existing fill, typically medium dense to very dense silty sand and sand with varying amounts of silt and gravel and localized zones of debris. This ESU was encountered directly below the ground surface in boring W-207-20 near Grade Separation Barrier 05.33R, boring W-215-20 near Wall 05.55L, and borings W-218-20, R2B-10-17, and R2B-11-17 near Wall 05.85L-B.

- **ESU 1C – Very Soft to Medium Stiff/Very Loose to Loose Fine-Grained Fill:** This ESU consists of existing fill comprised of soft lean clay and construction debris, including brick, coal, plaster, and burnt wood, in boring W-207-20 near Grade Separation Barrier 05.33R. A 16-foot-thick layer of ESU 1C was encountered below ESU 1B and above ESU 4B in boring W-207-20 near Grade Separation Barrier 05.33R.

- **ESU 2 – Coarse-Grained Recent Deposits**
  - **ESU 2A – Very Loose to Loose Sand/Gravel**: This ESU consists of very loose to medium dense silty sand with gravel. Wood may be present locally within this ESU. ESU 2A was encountered in borings H-1-85, H-2-85, and H-3-85 near Wall 05.85L-A and embankment EMB: I-405 SB MP 5.97 to 5.83. This ESU was encountered below ESU 1A and above ESU 2B in borings H-1-85, H-2-85, and H-3-85.
  - **ESU 2B – Medium Dense Sand/Gravel**: This ESU consists of loose to dense silty sand and sandy silt with varying amounts of gravel and organics. ESU 2B was encountered in borings H-2-85 and H-3-85 near Wall 05.85L-A and embankment EMB: I-405 SB MP 5.97 to 5.83, and in borings R2B-10-17, R2B-11-17, and W-218-20 near Wall 05.85L-B. Loose to medium dense soils in the unit encountered below the groundwater showed liquefaction potential in boring H-2-85 near Wall 05.85L-A.

- **ESU 4 – Glacially Consolidated Coarse-Grained Deposits**
  - **ESU 4B – Dense to Very Dense Sand/Gravel**. This ESU is typically composed of dense to very dense sand with varying amounts of silt and gravel. Very dense silt was encountered in ESU 4B in boring W-215-20 near Wall 05.55L. ESU 4B was encountered in all borings included in Appendix A of this geotechnical report. All borings included in Appendix A terminated in this unit.

ESU 5 – Glacially Consolidated Fine-Grained Deposits

- **ESU 5B – Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt**. This ESU consists of hard to very hard clay and hard/very dense silt. A zone of ESU 5B was encountered within ESU 4B in boring W-217-20 near Wall 05.85L-A and embankment EMB: I-405 SB MP 5.97 to 5.83, and in boring W-218-20 near Wall 05.85L-B.

5.3 Groundwater Conditions

The design groundwater elevations used in our engineering analyses were typically based on the highest groundwater levels reported on each respective boring log or the nearest available groundwater measurement. The groundwater levels used in design are shown on the design sections in Appendices C through G.

Groundwater was not observed in boring W-207-20 at Grade Separation Barrier 05.33R. We used a groundwater elevation of 117.3 feet at Bridge 23W based on groundwater observations at the time of drilling in nearby boring H-3-65.

At Wall 05.55L, we used groundwater observations at the time of drilling boring W-215-20 to define a groundwater level at approximately Elevation 140.2 feet.

At Wall 05.85L-A, groundwater was reported in borings H-1-85, H-2-85, and H-3-85 between Elevation 163 and 210 feet. These three borings were advanced in 1985. Groundwater was not observed in boring W-217-20, which was advanced in 2020. Because of the variability in groundwater observations, we developed a steady state seepage model to evaluate the groundwater level at Wall 05.85L-A. We used the piezometer data collected in 1985 from boring H-3-85 and measured groundwater at the time of drilling from boring H-2-85 to inform our model.

We also used the steady-state seepage analysis results at Wall 05.85L-A to model the groundwater level at the embankment. Discussion of our seepage analysis methodology and conclusions are presented in Sections 7.7 and 8.5, respectively. Steady-state seepage analysis results are presented in Appendix E.

Groundwater was not observed in boring W-218-20 at Wall 05.85L-B. Bail tests were performed in 2017 in borings R2B-10-17 and R2B-11-17. However, both of these borings were advanced using bentonite drilling fluid. In our experience, bail tests performed in borings advanced with bentonite drilling fluid can produce unreliable measurements of groundwater level. Therefore, we also used the steady-state seepage analysis results at Wall 05.85L-A to model the groundwater level at Wall 05.85L-B.

Discussion of our seepage analysis methodology and conclusions are presented in Sections 7.7 and 8.5, respectively. Steady-state seepage analysis results are presented in Appendix E.

6.0 Engineering Soil Properties

6.1 Design Soil Properties for Existing Soils

We selected design soil properties for each ESU based on the subsurface explorations, laboratory testing, and conditions described in the GDR, RFP reference documents, and explorations and laboratory testing completed by the design-build team. Soil properties were developed in accordance with the procedures outlined in the Geotechnical Soil Properties Methodology report for this project (Wood 2020).

A more detailed description of analyses completed for soil property development is included in Section 7.1 of this report. The analyses completed for soil property development for Grade Separation Barrier 05.33R; and Walls 05.55L, 05.85L-A, and 05.85L-B are presented in Appendices C through F, respectively. We applied the soil properties developed for Wall 05.85L-A (presented in Appendix E) to embankment EMB: I-405 SB MP 5.97 to 5.83 since we used the same borings to define the ESUs at the wall and the embankment. Soil properties selected for use in design of Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 are presented in Tables 3 through 6.

Table 3. Grade Separation Barrier 05.33R Soil Properties by Engineering Stratigraphic Unit (Existing Soil)

ESU	Description	Total Unit Weight, γ (pcf)	Strength Property		Elastic Modulus, Es (ksf)	Poisson's Ratio
			Effective Friction Angle, φ (degrees)	Effective Cohesion, c (psf)		
ESU 1B	Medium Dense to Very Dense Coarse-Grained Fill	120	36	0	725	0.35
ESU 1C	Very Soft to Medium Stiff/Very Loose to Loose Fine-Grained Fill	115	27	0	ND	ND
ESU 4B	Dense to Very Dense Sand/Gravel	130	43	0	ND	ND

Abbreviations:
ESU = Engineering Stratigraphic Unit
ND = not developed
ksf = kips per square foot
pcf = pounds per cubic foot
psf = pounds per square foot

Table 4. Wall 05.55L Soil Properties by Engineering Stratigraphic Unit (Existing Soil)

ESU	Description	Total Unit Weight, γ (pcf)	Strength Property		Elastic Modulus, Es (ksf)	Poisson's Ratio
			Effective Friction Angle, φ (degrees)	Effective Cohesion, c (psf)		
ESU 1B	Medium Dense to Very Dense Coarse-Grained Fill	130	40	0	800	0.40
ESU 4B	Dense to Very Dense Sand/Gravel	120	43	0	ND	ND

Abbreviations:
ESU = Engineering Stratigraphic Unit
ND = not developed
ksf = kips per square foot
pcf = pounds per cubic foot
psf = pounds per square foot

Table 5. Wall 05.85L-A and Embankment EMB: I-405 SB MP 5.97 to 5.83 Soil Properties by Engineering Stratigraphic Unit (Existing Soil)

ESU	Description	Total Unit Weight, γ (pcf)	Strength Property			Residual Strength, Sr (psf)	Elastic Modulus, Es (ksf)	Poisson's Ratio
			Effective Friction Angle, φ (degrees)	Effective Cohesion, c (psf)	Apparent Cohesion, c_{app} (psf)			
ESU 1A	Loose to Medium Dense Coarse-Grained Fill	110	34	0	ND	-	330[2]	ND
ESU 2A	Very Loose to Loose Sand/ Gravel	110	32	0	100	-	530[3]	0.33
ESU 2B	Medium Dense Sand/ Gravel	110	32	0	200	497[1]	800[2]	ND
ESU 4B	Dense to Very Dense Sand/ Gravel	130	43	0	ND	-	2,670[2]	ND
ESU 5B	Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	130	43	0	ND	-	ND	ND

Notes:
1. Residual shear strength was calculated for saturated, potentially liquefiable ESU 2B encountered in boring H-2-85 near Wall 05.85L-A. At embankment EMB: I-405 SB MP 5.97 to 5.83, ESU 2B was encountered above the groundwater, and therefore the residual strength value presented in the table above is not applicable to the embankment.

2. Elastic modulus estimated for elastic settlement evaluation at embankment EMB: I-405 SB MP 5.97 to 5.83.
3. Elastic modulus estimated for elastic settlement evaluation at Wall 05.85L-A and embankment EMB: I-405 SB MP 5.97 to 5.83.

Abbreviations:
ESU = Engineering Stratigraphic Unit
ND = not developed
ksf = kips per square foot
psi = pounds per square inch
pcf = pounds per cubic foot
psf = pounds per square foot

Table 6. Wall 05.85L-B Soil Properties by Engineering Stratigraphic Unit (Existing Soil)

ESU	Description	Total Unit Weight, γ (pcf)	Strength Property			Elastic Modulus, Es (ksf)	Poisson's Ratio
			Effective Friction Angle, φ (degrees)	Effective Cohesion, c (psf)	Apparent Cohesion, c_{app} (psf)		
ESU 1B	Medium Dense to Very Dense Coarse-Grained Fill	130	41	0	100	ND	ND
ESU 2B	Medium Dense Sand/Gravel	115	34	0	200	660	0.33
ESU 4B	Dense to Very Dense Sand/Gravel	130	43	0	ND	ND	ND
ESU 5B	Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	130	42	0	ND	ND	ND

Abbreviations:
ESU = Engineering Stratigraphic Unit
ND = not developed
ksf = kips per square foot
psi = pounds per square inch
pcf = pounds per cubic foot
psf = pounds per square foot

6.2 Design Soil Properties for Proposed Fill

Table 7 presents our selected design soil properties to be used for typical WSDOT-specified fill materials. The values shown are derived from Project GDM Section 5.12 and Table 5-2: Presumptive Design Property Ranges for Compacted Borrow and Other WSDOT Standard Specification Materials. The ranges of friction angle and total unit weight values provided in Project GDM Section 5.12 and Table 5-2 are shown in parentheses. We used lightweight expanded polystyrene (EPS) geofoam for backfill in our analyses of future I-405 widening above Walls 05.85L-A and 05.85L-B. Since the configuration we analyzed is

only one potential option for the forward compatible walls, we conservatively selected a high unit weight (above the range provided in Project GDM Section 5.12) and a low shear strength for the EPS properties.

Table 7. WSDOT Standard Fill Soil Properties (Proposed Fill)[1]

Material	WSDOT Standard Specification	Friction Angle[2], φ (degrees)	Cohesion, c (psf)	Total Unit Weight[2] (pcf)
Common Borrow	9-03.14(3)	32 (30 to 34)	0[3]	120 (115 to 130)
Select Borrow	9-03.14(2)	36 (34 to 38)	0	125 (120 to 135)
Gravel Borrow	9-03.14(1)	38 (36 to 40)	0	130 (130 to 145)
Gravel Borrow for Structural Earth Wall	9-03.14(4)	38 (36 to 40)	0	130 (130 to 145)
Gravel Backfill for Walls	9-03.12(2)	38 (36 to 40)	0	130 (125 to 135)
Quarry Spalls	9-13.1(5)	42 (40 to 45)	0	110 (105 to 120)
Expanded Polystyrene (EPS) Geofoam	See Note 4	0	100[5]	5[6] (1 to 2)

Notes:
1. Based on Project GDM Section 5.12 and Table 5-2.
2. Range of soil properties shown in parentheses.
3. 50psf apparent cohesion added in pseudo-static analyses for Wall 05.85L-B. See Section 8.7 for discussion.
4. Per Project GDM Section 5.12, EPS shall be manufactured according to ASTM C 303 for minimum density and ASTM D 1621 for compressive strength.
5. Shear strength is conservatively low.
6. Unit weight is conservatively high and outside the typical range.

Abbreviations:
ASTM = American Society for Testing and Materials
GDM = Geotechnical Design Manual
pcf = pounds per cubic foot
psf = pounds per square foot
WSDOT = Washington State Department of Transportation

7.0 Geotechnical Engineering Analysis Methodology

The following sections describe the methodology associated with the following geotechnical engineering analyses and evaluations:

- Soil property development,
- Seismic hazard analysis,
- Lateral earth pressures,
- Sliding coefficients of friction,
- Shallow foundation bearing resistance and elastic settlement,

- Consolidation settlement,
- Seepage analysis,
- Global stability, and
- Compound stability

7.1 Soil Property Development

7.1.1 General

Design soil properties were developed in accordance with the Project GDM, American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design Specifications, and Federal Highway Administration (FHWA) documents, using methods presented in the Geotechnical Soil Properties Methodology report for this project (Wood 2020). We calculated the average, geometric mean, and standard deviation within each ESU. We checked the reliability of the ESU data set by comparing the coefficient of variation (COV) of each calculated geometric mean value to measured and interpreted values presented in Sabatini et al. (2002) Table 52. Soil property development supporting calculations are provided in Appendices C through F.

7.1.2 Unit Weight

ESU unit weights were estimated using the procedure outlined in the Geotechnical Soil Properties Methodology report (Wood 2020) and the 2014 California Department of Transportation (CALTRANS) Geotechnical Manual Unified Soil Classification System (USCS) classification based on the field blow counts corrected for overburden pressure and hammer efficiency ($N1_{60}$).

We selected an initial unit weight for each soil sample based on the field (uncorrected) Standard Penetration Test (SPT) blow count and the soil classification. We used these initial unit weights to calculate the overburden pressure and develop $N1_{60}$ for each soil sample. Per CALTRANS, we used the developed $N1_{60}$ of each soil sample to revise our initial selected unit weights. Revised unit weights were used to estimate the geometric mean unit weight for each ESU. We used the geometric mean to assign a design unit weight for each ESU. Design unit weights are rounded to the nearest 5 pounds per cubic foot (pcf).

Initial unit weights selected for each soil sample are presented on the liquefaction input page for each boring in the Design Calculations section of Appendices C through F. Revised unit weights for each soil sample and design unit weights for each ESU are presented in the ESU Soil Property Calculations section of Appendices C through F.

7.1.3 $N1_{60}$ and Friction Angle

$N1_{60}$ and friction angles were developed in accordance with the Project GDM Section 5.5 and Table 5-1, respectively, using a spreadsheet developed by GeoEngineers.

For each ESU, we used the design fines content to estimate the design friction angle from the range of values presented in the Project GDM Table 5-1. For soils not subjected to glacial consolidation, the friction angle range lower limit was selected for design fines contents greater than 30 percent and the upper limit was selected for design fines contents less than 5 percent. For non-glacially consolidated ESUs with design fines contents between 5 percent and 30 percent, friction angles were selected by interpolation between the upper and lower limits presented in the Project GDM Table 5-1. For glacially consolidated soils, we capped the friction angle at 43 degrees for ESUs with design fines contents less than 70 percent and used the interpolated friction angle for ESUs with fines contents greater than 70 percent.

7.1.4 Apparent Cohesion

Apparent cohesion values were developed for surficial ESUs in accordance with FHWA Geotechnical Engineering Circular No. 3, Table 11-2 based on the selected design fines content of the ESU. Where the groundwater is present within or intersects an ESU, apparent cohesion was applied only to ESUs in which the majority of the ESU layer was above the groundwater table. Per Project GDM Section 5.10, apparent cohesion values were only used in pseudo-static global and compound stability analyses.

7.1.5 Elastic Modulus and Poisson's Ratio

We used soil type and density/consistency to estimate the ESU elastic modulus and Poisson's ratio from empirical relationships presented in AASHTO LRFD Table C10.4.6.3-1.

7.1.6 Hydraulic Conductivity

We estimated the hydraulic conductivity of saturated, normally consolidated ESU 2A and ESU 2B using the Schlichter method as outlined in the WSDOT Highway Runoff Manual (HRM). We selected hydraulic conductivities for glacially consolidated ESU 4B and ESU 5B based on the Laprade and Robinson (1989) values presented in Table 2 of the United States Geological Survey (USGS) Open-File Report 00-228. Hydraulic conductivities were used in the seepage analysis (described in Sections 7.7 and 8.5).

7.2 Seismic Hazard Analysis

7.2.1 Ground Motion Parameters

The project site is located within a seismically active area. To select appropriate seismic design parameters, we first evaluated site class at each relevant boring using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 3.10.3.1. Because the explorations did not extend to 100 feet below the ground surface (bgs), we extrapolated soil conditions beyond the bottom of the boring. We selected a design site class for the barriers, walls, and embankment, considering the distribution of site classes represented by the borings as well as the depths of the borings and the amount of extrapolation to 100 feet bgs.

Seismic design parameters for this project were developed using the WSDOT Bridge Engineering Software BEToolbox/BridgeLink in accordance with the WSDOT BDM. Seismic parameters, including the peak ground acceleration (PGA) and site class adjusted PGA (A_s), were derived directly from the BEToolbox/BridgeLink software using the latitude, longitude, and design site class of each barrier, wall, and embankment. Per Project GDM Section 6.3.1, the ground motion parameters for design of the barrier, walls, and the embankment are based on the projected ground motion at the project site that has a 7 percent (Safety Evaluation Earthquake [SEE]) probability of exceedance in a 75-year period (approximate 1,000-year return period).

Per the National Cooperative Highway Research Program (NCHRP) Report 611 and AASHTO LRFD Section A11.5.2, A_s can be corrected to account for wave scattering effects (vertical variations in the average ground acceleration) for retaining walls, slopes, and wall-slope combinations greater than 20 feet in height by applying a wave scatter coefficient, α, to A_s. In addition, a 50 percent reduction can be applied to A_s for flexible wall systems and slopes capable of 1- to 2-inch displacements during the design seismic event.

Based on the Hart Crowser seismic design report "I-405 R2B Segment 1a Site-Specific Hazard Analysis RFU," dated March 25, 2021, the mean earthquake magnitude at the PGA period is 6.97 for site class C and 7.0 for site class D for the SEE.

Design site class and A_s for Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 are presented in Section 8.1.1. The WSDOT BEToolbox/BridgeLink software outputs, calculations of corrected A_s for Walls 05.85L-A and 05.85L-B, and our site class calculations are provided in Appendices C through F.

7.2.2 Liquefaction Potential

We evaluated the factor of safety (FS) against liquefaction and liquefaction-induced settlement of saturated, very loose to medium dense soils in accordance with Chapter 6 of the Project GDM using a spreadsheet developed by GeoEngineers. The spreadsheet uses methodology from Youd et al. (2001) and Idriss and Boulanger (2008 with 2014 updates) to identify liquefaction potential. Per Section 6-4.2.3 of the Project GDM, soils with liquefaction potential are defined as those with FS against liquefaction less than 1.2.

Liquefaction potential is presented in Section 8.1.2, and supporting calculations are provided in Appendices C through F.

7.2.3 Residual Shear Strength

Residual shear strength was calculated for liquefiable soils from existing relationships and procedures outlined in Project GDM Section 6-2.2 using a spreadsheet developed by GeoEngineers. Residual strength calculations become unconservatively high for liquefiable soils with an $N1_{60}$ corrected to an equivalent clean sand [$N1_{60}$(cs)] that is greater than 20. Using guidance presented in WSDOT Report WA-RD 668.1 (Kramer 2008), we capped $N1_{60}$(cs) at 20 to calculate a residual shear strength for soils exhibiting liquefaction potential (FS against liquefaction < 1.2).

Residual shear strengths are presented in Section 8.1.3 and supporting calculations are provided in Appendix E.

7.3 Lateral Earth Pressures

Imported backfill will be placed between the existing and proposed grades at Grade Separation Barrier 05.33R and Walls 05.55L, 05.85L-A, and 05.85L-B. At Walls 05.85L-A and 05.85L-B, imported fill will also be placed within the reinforced zone and between the reinforced zone and the face of the temporary shoring.

Lateral earth pressures for native soils and imported fill materials were calculated in accordance with AASHTO LRFD 3.11.5 for the proposed slopes in front of and behind the barrier and walls. In addition, active lateral earth pressures on Grade Separation Barrier 05.33R were calculated using a barrier back face batter of 4H:21V (10.8 degrees from vertical).

We analyzed seismic earth pressures for Walls 05.55L, 05.85L-A, and 05.85L-B. Seismic earth pressures on Wall 05.55L were calculated in accordance with AASHTO LRFD Section 11.6.5.3 using the Mononobe-Okabe (M-O) Method. Seismic earth pressures on Walls 05.85L-A and 05.85L-B were developed using the Generalized Limit Equilibrium (GLE) Method in accordance with AASHTO LRFD Section A11.3.3 and NCHRP Report 611 Section 7.4. The GLE analysis was evaluated for Spencer's method using the computer design software Slope/W (Geo Slope International, Ltd. 2020). To calculate seismic earth pressures, we used a modified horizontal seismic coefficient, kh, coupling a 50 percent reduction for flexible wall displacements with a reduction for wave scattering effects.

Lateral earth pressures and load factor recommendations are presented in Section 8.2. Supporting calculations are provided in Appendices C through F.

7.4 Sliding Coefficients of Friction

Coefficients of friction for sliding were calculated using AASHTO LRFD equation 10.6.3.4-2. Sliding coefficients were calculated for CIP and precast concrete barriers at Grade Separation Barrier 05.33R, and for CIP concrete footings at Wall 05.55L on surficial native soils and imported fills. Per AASHTO LRFD Section 11.10.5.3, sliding coefficients of friction for Walls 05.85L-A and 05.85L-B were calculated for SEW discontinuous reinforcements (strips). For the discontinuous reinforcements at Walls 05.85L-A and 05.85L-B, sliding coefficients of friction were calculated using the friction angle of the foundation soil (surficial native soils or imported fills) or the reinforced fill soil (gravel borrow for structural earth wall), whichever was less.

Sliding coefficients are presented in Section 8.3. Supporting calculations are provided in Appendices C through F.

7.5 Shallow Foundation Bearing Resistance and Elastic Settlement

Bearing resistance for nominal (unfactored), Service, Strength, and Extreme Event Limit States was calculated using a spreadsheet developed by GeoEngineers in accordance with the methodology described in AASHTO LRFD Section 10.6.3. We estimated elastic settlement for the barriers and walls from procedures outlined in AASHTO LRFD Section 10.6.2.4. Sliding and overturning of the barrier and walls are being evaluated by the design-build team's wall designers and will be submitted under separate cover.

We estimated the bearing resistance and elastic settlement of the barrier and walls for the following effective widths:

- Grade Separation Barrier 05.33R– effective barrier widths between 2 and 6 feet
- Wall 05.55L – effective footing widths between 3 and 11 feet
- Wall 05.85L-A – effective SEW widths between 5 and 25 feet
- Wall 05.85L-B – effective SEW widths between 5 and 21 feet

We estimated the static elastic settlement of embankment EMB: I-405 SB MP 5.97 to 5.83 following the placement of new fill (common borrow) using the computer design software Settle3 (Rocscience 2021). We modeled the applied fill load along the approximate length of the embankment (160 feet) and the approximate length of the fill slope (80 feet) at the design section. We used the elastic moduli of the ESUs presented in Table 5 to evaluate immediate settlement of the embankment.

Bearing resistance and elastic settlement results are presented in Section 8.4. Supporting calculations are provided in Appendices C through F. Settle3 output reports for embankment EMB: I-405 SB MP 5.97 to 5.83 are provided in Appendix H.

7.6 Consolidation Settlement

Compressible soils, such as organic soil or normally consolidated/slightly over consolidated high plasticity silts or clays, were not identified in the explorations near Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83. Therefore, we do not anticipate long-term consolidation settlement to occur as a result of new loads.

7.7 Seepage Analysis

Seepage analysis was performed using the finite element seepage modeling software, Seep/W (Geo Slope International, Ltd. 2020) to estimate a steady state groundwater level for Wall 05.85L-A. Groundwater levels developed in the seepage analysis for Wall 05.85L-A were also used in our evaluations of Wall 05.85L-B, and embankment EMB: I-405 SB MP 5.97 to 5.83. We used existing groundwater measurements from piezometers in borings H-2-85 and H-3-85, soil hydraulic conductivity properties, and typical local precipitation data to develop a model of groundwater conditions and seepage patterns.

A discussion of the model development and conclusions is presented in Section 8.5 and the steady-state seepage results are presented in Appendix E. Seep/W output reports are provided in Appendix I.

7.8 Global Stability

Global stability was evaluated using limit equilibrium analysis following the procedure outlined in the Project GDM. We evaluated global stability of Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 using the computer design software Slope/W (Geo Slope International, Ltd. 2020). Factors of safety were developed using both Spencer's method and the Morgenstern-Price method with entry and exit search limits for a circular failure surface.

We modeled Grade Separation Barrier 05.33R and Wall 05.55L as a "High Strength" material having a unit weight of 150 pcf. We modeled the SEW and forward compatible walls at Walls 05.85L-A and 05.85L-B as a "High Strength" material having a unit weight of 130 pcf. We used the design backfill properties presented in Table 7 for the materials listed below at the following fill locations:

- Backfill behind Grade Separation Barrier 05.33R and Wall 05.55L – common borrow
- Backfill between reinforced zone and temporary shoring at Walls 05.85L-A and 05.85L-B – gravel borrow
- Fill between existing and proposed grades for Walls 05.85L-A and 05.85L-B – common borrow
- Backfill behind forward compatible walls at Walls 05.85L-A and 05.85L-B - EPS
- Embankment fill (EMB: I-405 SB MP 5.97 to 5.83) – common borrow
- Rock buttress to mitigate 1985 fill slope failure (EMB: I-405 SB MP 5.97 to 5.83) – gravel borrow and quarry spalls.

Grade Separation Barrier 05.33R will be designed in accordance with WSDOT BDM Section 10.3.1 for differential grade concrete barriers of 4 feet or less. Grade Separation Barrier 05.33R and embankment EMB: I-405 SB MP 5.97 to 5.83 follow procedures in Project GDM Chapter 9 for embankments to evaluate global stability. Per Project GDM Section 9.2.3.1, seismic global stability analyses are not required for the barrier or the embankment since they are not supporting or potentially impacting structures.

The Hart Crowser Released for Use (RFU) geotechnical letter "Design Requirements and Geotechnical Assessment of Retaining Walls" dated January 26, 2021, defines the minimum allowable distance to the travel lane (MADTL) as the "the minimum distance the wall must exist from the travel lane to prevent an elevation change of greater than 1 foot". If the MADTL is less than the distance between the wall and the travel lane, seismic failure of the wall will not severely impact the traveled way or compromise the life safety of the public, and therefore a detailed seismic analysis is not necessary. Based on Figure 1A in the Hart Crowser RFU geotechnical letter, the MADTL at Wall 05.55L is 6.4 feet. It is our understanding that an 8-foot-wide shoulder will separate the back of Wall 05.55L and the travel lane. According to the criteria outlined in the Hart Crowser RFU geotechnical letter noted above, a seismic slope instability analysis is not required for Wall 05.55L since collapse of the wall would not affect the travel lane or compromise public safety.

For pseudo-static analyses of Walls 05.85L-A and 05.85L-B, we used an apparent cohesion in surficial native soils based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3.

We evaluated post-seismic global stability using residual shear strengths for potentially liquefiable soil.

A uniform traffic surcharge of 250 pounds per square foot (psf) was included in the static global stability analysis where a roadway is present above the wall or barrier. In accordance with Section 15-4.12 of the Project GDM, we used a load factor of 1.0 for traffic surcharge for the static global stability analysis because it is a non-structural load. A uniform traffic surcharge of 125 psf, which is 50 percent of the static traffic surcharge, was included in the seismic (pseudo-static and post-seismic) global stability analyses where a roadway is present above the wall. Per AASHTO LRFD Section 3.4.1, we used an extreme event limit state load factor of 0.5 for the traffic surcharge for the seismic (pseudo-static and post-seismic) global stability analyses.

Groundwater levels were modeled using a piezometric surface. The piezometric surface was based on measured or observed groundwater levels at Grade Separation Barrier 05.33R and Wall 05.55L. We used the results from the seepage analysis to model the piezometric surface at Walls 05.85L-A and 05.85L-B, and embankment EMB: I-405 SB MP 5.97 to 5.83.

The results of our global stability analyses for Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 are presented in Section 8.6. Global stability models showing FS for critical failures at the design sections are provided in Appendices C through G. Slope/W output reports for global stability are provided in Appendix J.

7.9 Compound Stability

We evaluated compound stability at Walls 05.85L-A and 05.85L-B using the computer design software Slope/W (Geo Slope International, Ltd. 2020) to perform limit equilibrium analysis following the procedure outlined in Project GDM Section 15-5.3.4. Factors of safety were developed using both Spencer's method and the Morgenstern-Price method with entry and exit search limits for a circular failure surface.

We modeled the soil reinforcements as inextensible ribbed steel strips connected to precast concrete facing panels. The reinforcing strips are 2 inches wide and 5/32 inches thick grade 65 steel with galvanized corrosion protection. We calculated the corrosion loss over 75 years using steel corrosion rates presented in AASHTO LRFD Section 11.10.6.4.2a and FHWA Geotechnical Engineering Circular No. 11 Tables 3-7 and 3-8. We used the Reinforced Earth Company (RECO) standard precast concrete 5 feet by 5 feet facing panel "A" shop drawings provided in Project GDM Appendix 15-I to model the spacing of the reinforcing strips. Based on the facing panel "A" layout, each panel contains 2 rows and each row contains 2 reinforcing strips.

We applied resistance factors presented in AASHTO LRFD Section 11.5 and FHWA Geotechnical Engineering Circular No. 11 Table 4-7 to calculate the pullout resistance and tensile capacity of the reinforcing strips. We modeled the reinforced fill as gravel borrow with a coefficient of uniformity (Cu) of 6.3. Per AASHTO LRFD Section 11.10.6.3.2 and FHWA Geotechnical Engineering Circular No. 11 Section 3.4.2, a pullout resistance factor, F*, is equivalent to 2.0 at the ground surface when Cu is equal to or greater than 6.3. The reinforced zone fill, Gravel Borrow for Structural Earth Wall, imported during construction shall have a minimum Cu value of 6.3, as specified in Section 8.13.4. We used an F* of 2.0 at the ground surface to estimate the pullout resistance of the reinforcing strips. We used the pullout resistance to calculate an interface shear friction angle at each reinforcing strip, considering the strip width and spacing. The calculated tensile capacity and interface shear friction angles were input into Slope/W to model the reinforcing strips in the reinforced zone.

For pseudo-static analyses of Walls 05.85L-A and 05.85L-B, we used an apparent cohesion in the surficial native soils based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3.

We evaluated post-seismic compound stability using residual shear strengths for potentially liquefiable soil.

Per Project GDM Section 15-5.3.4 and AASHTO LRFD Table 3.4.1-1, a strength limit state load factor of 1.75 was applied to the standard traffic surcharge of 250 psf directly over the reinforced zone, resulting in a uniform traffic surcharge of 437.5 psf directly over the reinforced zone and a uniform traffic surcharge of 250 psf outside of the reinforced zone in the static compound stability analysis of Walls 05.85L-A and 05.85L-B. Per AASHTO LRFD Section 3.4.1, an extreme event limit state load factor of 0.5 was applied to the standard traffic surcharge of 250 psf, resulting in a uniform traffic surcharge of 125 psf across all traffic lanes (both directly over and outside the reinforced zone) for the seismic (pseudo-static and post-seismic) compound stability analyses.

Groundwater levels for Walls 05.85L-A and 05.85L-B were modeled using a piezometric surface based on the results from the seepage analysis at Wall 05.85L-A.

The results of our compound stability analyses for Walls 05.85L-A and 05.85L-B are presented in Section 8.7. Compound stability models showing FS for critical failures at the design sections are provided in Appendices E and F. Slope/W output reports for compound stability are provided in Appendix K.

8.0 Conclusions and Recommendations

8.1 Seismic Design

8.1.1 Ground Motion Parameters

We selected the design site class for the barrier, walls, and embankment using SPT blow counts of nearby explorations and the methodology presented in AASHTO LRFD Section 3.10.3.1. Ground motion parameters for a ground motion with 7 percent probability of exceedance in a 75-year period (approximate 1,000-year return period) (SEE hazard level) were developed using the WSDOT Bridge Engineering Software BEToolbox/BridgeLink. Based on deaggregation data from Hart Crowser (2021), we used a mean earthquake magnitude of 6.97 for site class C and 7.0 for site class D for the SEE.

We used a horizontal seismic acceleration coefficient (kh) to estimate seismic lateral earth pressures and evaluate pseudo-static global and compound stability. For our analyses, kh is reduced to 50 percent of A_s ($kh = 0.5 * A_s$) for flexible wall displacements of 1- to 2-inches, and reduced for the wall height-dependent seismic coefficient (wave scatter coefficient), α ($kh = \alpha * A_s$) for wave scattering effects. Per AASHTO LRFD Section 11.6.5.2.2, the wall height was taken as the distance from the bottom of the back of the wall to the ground surface directly above the back of the wall for seismic lateral earth pressure analyses. For global and compound pseudo-static analyses, wave scatter was based on the height of the failure surface mobilized in the design seismic event. Wave scatter reductions were not applied for heights less than 20 feet.

The representative design site class, SEE A_s, and kh are summarized in Table 8. WSDOT BDM software outputs, site class determination, and wave scatter calculations are provided in Appendices C through F.

Table 8. Design Site Class and Adjusted Peak Ground Acceleration Parameters

Design Element	Site Class	SEE A_s	Seismic Analysis	Wave Scatter Coefficient, α (Proposed/FC)	Horizontal Seismic Acceleration Coefficient, kh ($kh = 0.5 * \alpha * A_s$) (Proposed/FC)
Grade Separation Barrier 05.33R[1]	D	0.505	Lateral Earth Pressure	Not Applicable	0.253
Wall 05.55L[2]	D	0.505	Lateral Earth Pressure	Not Applicable	0.253
Wall 05.85L-A	D	0.505	Lateral Earth Pressure	0.815	0.206
			Global Stability	0.753 / 0.756	0.190 / 0.191
			Compound Stability	0.765 / 0.765	0.193 / 0.193
Wall 05.85L-B	C	0.520	Lateral Earth Pressure	0.808	0.210
			Global Stability	0.755 / 0.756	0.196/ 0.197
			Compound Stability	0.799 / 0.753	0.208 / 0.196
Embankment EMB: I-405 SB MP 5.97 to 5.83[1,3]	D	0.505	Not Applicable	Not Applicable	Not Applicable

Notes:
1. Per Project GDM Section 9.2.3.1, seismic stability analyses are not required.

2. Per Hart Crowser's RFU geotechnical letter "Design Requirements and Geotechnical Assessment of Retaining Walls" (2021), seismic stability analyses are not required.
3. Lateral earth pressures are not applicable for the embankment.

Abbreviations:
A_s = site class adjusted peak ground acceleration
FC = forward compatible wall
SEE = Safety Evaluation Earthquake

8.1.2 Liquefaction and Liquefaction-Induced Settlement

We analyzed the borings at the barrier, wall, and embankment locations for liquefaction potential of saturated, loose to medium dense soil. We used the SEE A_s for our liquefaction evaluation.

Potentially liquefiable soil was not encountered in any of the borings near Grade Separation Barrier 05.33R, Wall 05.55L, and Wall 05.85L-B. Potentially liquefiable soil was encountered in boring H-2-85 near Wall 05.85L-A and embankment EMB: I-405 SB MP 5.97 to 5.83. Based on our review, saturated, low-plasticity portions of ESU 2B at Wall 05.85L-A may be liquefiable. Estimated liquefaction related settlement ranges from 2 to 4 inches, considering the full thickness of ESU 2B present at H-2-85. We estimate that differential liquefaction settlements in ESU 2B could be on the order of 1 to 2 inches. However, based on the planned base of wall elevation, we do not anticipate that a significant thickness of ESU 2B will remain below the base of the wall. In addition, based on our groundwater model, we anticipate that any ESU 2B material remaining below the wall will not be saturated. Therefore, we do not anticipate liquefaction or related settlement of soil beneath the wall. Saturated portions of ESU 2B downslope of the wall may experience liquefaction and related settlement.

We used boring H-2-85 to develop the soil properties at embankment EMB: I-405 SB MP 5.97 to 5.83. Based on our interpretation of the subsurface, ESU 2B is above the groundwater table at the embankment and therefore, potentially liquefiable soils were not encountered at the embankment.

In our analysis, we did not allow glacially consolidated deposits (ESU 4B and ESU 5B) to liquefy.

Details of our liquefaction analyses, including plots and liquefaction spreadsheet input and output pages, are provided in Appendices C through F. Summaries of our liquefaction results for the barrier, walls, and embankment during the design SEE event are presented in Tables 9 through 12 below. Potential impacts of liquefaction on global and compound stability are addressed in Sections 8.6 and 8.7, respectively.

Table 9. Grade Separation Barrier 05.33R Liquefaction Summary

Boring Designation	Liquefaction (Y/N)	Top of Boring Elevation (NAVD 88) (feet)	Groundwater Elevation[1] (NAVD 88) (feet)	Estimated Liquefaction Depth Range (feet)	Estimated Liquefaction Elevation Range (NAVD 88) (feet)	Estimated Cumulative Settlement Range (inch)
W-207-20	N	128.2	117.3	-	-	-

Notes:
1. Groundwater elevation based on piezometric data in nearby boring H-3-65.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
Y/N = Yes/No

Table 10. Wall 05.55L Liquefaction Summary

Boring Designation	Liquefaction (Y/N)	Top of Boring Elevation (NAVD 88) (feet)	Groundwater Elevation[1] (NAVD 88) (feet)	Estimated Liquefaction Depth Range (feet)	Estimated Liquefaction Elevation Range (NAVD 88) (feet)	Estimated Cumulative Settlement Range (inch)
W-215-20	N	171.2	140.2	-	-	-

Notes:
1. Groundwater elevation based on observations at time of drilling.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
Y/N = Yes/No

Table 11. Wall 05.85L-A and Embankment EMB: I-405 SB MP 5.97 to 5.83 Liquefaction Summary

Boring Designation	Liquefaction (Y/N)	Top of Boring Elevation (NAVD 88) (feet)	Groundwater Elevation[1] (NAVD 88) (feet)	Estimated Liquefaction Depth Range (feet)	Estimated Liquefaction Elevation Range (NAVD 88) (feet)	Estimated Cumulative Settlement Range (inch)
W-217-20	N	219.6	209.0	-	-	-
H-1-85	N	200.6	181.0	-	-	-
H-2-85	Y[2]	186.1	162.0	24 to 36	162.1 to 150.1	2 to 4
H-3-85	N	216.0	186.0	-	-	-

Notes:
1. Groundwater elevation based on results from seepage analysis at Wall 05.85L-A.
2. Potentially liquefiable soils were encountered at Wall 05.85L-A. Potentially liquefiable soils were not encountered at embankment EMB: I-405 SB MP 5.97 to 5.83.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
Y/N = Yes/No

Table 12. Wall 05.85L-B Liquefaction Summary

Boring Designation	Liquefaction (Y/N)	Top of Boring Elevation (NAVD 88) (feet)	Groundwater Elevation[1] (NAVD 88) (feet)	Estimated Liquefaction Depth Range (feet)	Estimated Liquefaction Elevation Range (NAVD 88) (feet)	Estimated Cumulative Settlement Range (inch)
W-218-20	N	238.6	210.0	-	-	-
R2B-11-17	N	219.2	199.0	-	-	-
R2B-10-17	N	210.2	194.0	-	-	-

Notes:
1. Groundwater elevation based on seepage analysis at Wall 05.85L-A.

Abbreviations:
NAVD 88 = North American Vertical Datum of 1988
Y/N = Yes/No

8.1.3 Residual Shear Strength

We evaluated post-earthquake residual shear strengths of saturated, loose to medium dense soil exhibiting liquefaction potential. Residual shear strengths were estimated for potentially liquefiable soil identified in ESU 2B in boring H-2-85 at Wall 05.85L-A. We applied a residual shear strength to portions of ESU 2B below the water table in our post-seismic global and compound stability analyses at Wall 05.85L-A.

The calculated residual shear strength of liquefiable soils is provided on the liquefaction spreadsheet output pages in Appendix E. For our analysis of Wall 05.85L-A, we used the geomean residual shear strength of 497 psf calculated in Appendix E and presented in Table 5.

8.2 Lateral Earth Pressures

We estimated the lateral earth pressures of the backfill placed between the existing and proposed grades at Grade Separation Barrier 05.33R and Wall 05.55L. At Grade Separation Barrier 05.33R and Wall 05.55L, the backfill will consist of compacted common borrow or better imported fill; in our analyses, we estimated the lateral earth pressures of common borrow, select borrow, and gravel borrow at Grade Separation Barrier 05.33R and Wall 05.55L. We used a 4H:21V (10.8 degrees from vertical) batter on the back face of the barrier to calculate lateral earth pressures. We evaluated a 3.2H:1V (17.5 degrees from horizontal) backslope for Grade Separation Barrier 05.33R and a 3.7H:1V (15 degrees from horizontal) foreslope for Wall 05.55L. We applied an interface friction angle, δ, equal to two-thirds of the backfill friction angle to estimate the active earth pressures on Wall 05.55L; we did not apply a δ to Grade Separation Barrier 05.33R.

We estimated the active static and active static + seismic lateral earth pressures for Grade Separation Barrier 05.33R and Wall 05.55L using the M-O method. Per AASHTO LRFD Section 11.6.5.2.2, the seismic horizontal acceleration coefficient, kh, can be reduced to 50 percent of A_s for retaining structures capable of 1- to 2-inches of displacement during the design seismic event. Accordingly, we reduced kh to 50 percent of As to evaluate the active static + seismic earth pressures. The kh value used in our analysis for Grade Separation Barrier 05.33R and Wall 05.55L is presented in Table 8.

At Walls 05.85L-A and 05.85L-B, the backfill between the reinforced zone and the temporary shoring will consist of gravel backfill for walls. However, since this backfill zone will be relatively thin, we conservatively estimated active static lateral earth pressures for native soils ESU 2A and ESU 2B behind Walls 05.85L-A and 05.85L-B, respectively. We evaluated the lateral earth pressures for a 2H:1V (27 degrees from horizontal) backslope at each wall, with a 2H:1V (27 degrees from horizontal) and a 3.7H:1V (15 degrees from horizontal) foreslope at Walls 05.85L-A and 05.85L-B, respectively. Per AASHTO LRFD Section 11.10.5.2, we applied a δ equal to two-thirds of the retained soil friction angle for Walls 05.85L-A and 05.85L-B.

We estimated the active static lateral earth pressures for Walls 05.85L-A and 05.85L-B using the M-O method. We estimated the active static + seismic lateral earth pressures for Walls 05.85L-A and 05.85L-B using the GLE method. To evaluate the active static + seismic earth pressures at the back of the walls, we removed the SEW and all soil directly above the SEW in our models to simulate the interface between the reinforced soil and the retained soil. We applied a force at the face of the retained soil at heights of one-third and one-half from the base of the wall to determine the maximum active static + seismic earth pressure. The applied force was inclined at the friction angle of ESU 2A and ESU 2B at Walls 05.85L-A and 05.85L-B, respectively. We varied the magnitude of the force until a FS equal to 1.0 was achieved. We back-calculated the active static + seismic earth pressure coefficient, kae, and active static + seismic lateral earth pressure from the selected maximum seismic force on the wall.

Per the Project GDM and AASHTO, flexible SEWs are capable of 1- to 2-inches of displacement during the design seismic event, and therefore the seismic horizontal acceleration coefficient, kh, can be reduced to 50 percent of A_s to evaluate seismic earth pressures. Per AASHTO and NCHRP Report 611, kh can be further reduced for wave scattering effects using the height-dependent seismic coefficient (wave scatter coefficient), α. We applied the reduction for flexible wall systems and wave scatter to kh for the seismic earth pressure analyses using the GLE method for Walls 05.85L-A and 05.85L-B. The kh value used in our analyses for Walls 05.85L-A and 05.85L-B is presented in Table 8.

Passive resistance for Grade Separation Barrier 05.33R and Walls 05.55L, 05.85L-A, and 05.85L-B shall be ignored due to the shallow embedment and foreslope condition at the barrier and walls. Active static lateral earth pressure coefficients, ka, and active static + seismic earth pressure coefficients, kae, and the corresponding lateral earth pressures on the back of Grade

Separation Barrier 05.33R and Walls 05.55L, 05.85L-A, and 05.85L-B are presented in Table 13. We recommend active lateral earth pressures be applied using a triangular distribution. We recommend applying an LRFD load factor of 1.5 to the static earth pressures in accordance with AASHTO LRFD Table 3.4.1-2 and an LRFD load factor of 1.0 to the static + seismic earth pressures in accordance with AASHTO LRFD Table 3.4.1-1. Supporting calculations are provided in Appendices C through F. Appropriate surcharge loads (such as traffic loading, fill loads above the barrier and walls, and forward compatible loads) and the corresponding load factors shall be applied when evaluating wall stability. All surcharge loads shall apply load factors in accordance with AASHTO LRFD Tables 3.4.1-1 and 3.4.1-2.

Table 13. Grade Separation Barrier 05.33R, and Walls 05.55L, 05-85L-A, and 05.85L-B
Active Lateral Earth Pressure Coefficients and Active Lateral Earth Pressures[1,2]

Design Element	Foreslope (degrees)	Backslope (degrees)	Material	Active Lateral Earth Pressure Coefficient		Active Lateral Earth Pressure (pcf)[1, 2]	
				Static, ka	Static + Seismic, kae	Static	Static + Seismic
Grade Separation Barrier 05.33R[3]	0	17.5	Common Borrow	0.49	1.04	59*H	125*H
			Select Borrow	0.42	0.76	52*H	95*H
			Gravel Borrow	0.39	0.69	50*H	90*H
Wall 05.55L	15	0	Common Borrow	0.28	0.48	33*H	57*H
			Select Borrow	0.23	0.42	29*H	53*H
			Gravel Borrow	0.22	0.39	28*H	51*H
Wall 05.85L-A	27	27	ESU 2A (static) Retained Native Soil (static + seismic)	0.46	0.87	51*H	95*H
Wall 05.85L-B	15	27	ESU 2B (static) Retained Native Soil (static + seismic)	0.41	1.1	47*H	126*H

Notes:
1. Active lateral earth pressures (static and static + seismic) shall be applied using a triangular distribution.
2. Earth pressures do not include surcharge loads, such as traffic loading or forward compatible wall loading.
3. Barrier back face batter = 4H:21V (horizontal:vertical)

Abbreviations:
ESU = Engineering Stratigraphic Units
H = Height of the retained soil behind the wall

8.3 Sliding Coefficients of Friction

We used AASHTO LRFD equation 10.6.3.4-2 to estimate the sliding coefficients of friction for native soils and for imported fills (common borrow, select borrow, and gravel borrow) beneath the barrier and walls.

Sliding coefficients for CIP and precast concrete barriers for Grade Separation Barrier 05.33R and CIP concrete footings for Wall 05.55L are presented in Table 14 and supporting calculations are provided in Appendices C and D. Sliding coefficients for SEW discontinuous reinforcements for Walls 05.85L-A, and 05.85L-B are presented in Table 15 and supporting calculations are provided in Appendices E and F.

Table 14. Grade Separation Barrier 05.33R and Wall 05.55L Sliding Coefficients of Friction

Grade Separation Barrier/Wall	Foundation Material	Sliding Coefficients of Friction	
		CIP Barrier	Precast Barrier
Grade Separation Barrier 05.33R	ESU 1B	0.73	0.58
	Common Borrow	0.62	0.50
	Select Borrow	0.73	0.58
	Gravel Borrow	0.78	0.63
Wall 05.55L	ESU 1B	0.84	Not Applicable
	Common Borrow	0.62	Not Applicable
	Select Borrow	0.73	Not Applicable
	Gravel Borrow	0.78	Not Applicable

Abbreviations:
CIP = cast-in-place
ESU = Engineering Stratigraphic Unit

Table 15. Walls 05.85L-A and 05.85L-B Sliding Coefficients of Friction

Wall	Foundation Material	Sliding Coefficients of Friction – Discontinuous Reinforcements
05.85L-A	ESU 2A	0.62
	Common Borrow	0.62
	Select Borrow	0.73
	Gravel Borrow	0.78
05.85L-B	ESU 2B	0.67
	Common Borrow	0.62
	Select Borrow	0.73
	Gravel Borrow	0.78

Abbreviations:
ESU = Engineering Stratigraphic Unit

8.4 Shallow Foundation Bearing Resistance and Elastic Settlement

We evaluated bearing resistance for effective footing widths of 2 to 6 feet at Grade Separation Barrier 05.33R, 3 to 11 feet at Wall 05.55L, 5 to 25 feet at Wall 05.85L-A, and 5 to 21 feet at Wall 05.85L-B. For Grade Separation Barrier 05.33R and Wall 05.55L, our bearing resistance calculations include resistance factors of 0.55 (Strength Limit State), 1.0 (Service Limit State), and 0.8 (Extreme Event Limit State) for semi-gravity walls per AASHTO LRFD Table 11.5.7.1 and AASHTO LRFD Section 11.5.8. For Walls 05.85L-A and 05.85L-B, our bearing resistance calculations include resistance factors of 0.65 (Strength Limit State), 1.0 (Service Limit States), and 0.9 (Extreme Event Limit State) for MSE (SEW) per AASHTO LRFD Table

11.5.7.1 and AASHTO LRFD Section 11.5.8. Sliding, overturning, and internal stability are being evaluated by the design-build team's wall designers and will be submitted under separate cover.

Bearing resistances for Grade Separation Barrier 05.33R and Walls 05.55L, 05.85L-A, and 05.85L-B are presented in Tables 16 through 19. As noted in Section 8.9.3 below, all soft, loose, or otherwise unsuitable soils observed in foundation excavations shall be removed and replaced with compacted structural fill.

Table 16. Grade Separation Barrier 05.33R Bearing Resistance and Elastic Settlement

Effective Footing Width, B (feet)	Unfactored Bearing Resistance (ksf)	Extreme Event Limit State Bearing Resistance (ksf)	Strength Limit State Bearing Resistance (ksf)	Service Limit State Bearing Resistance (ksf)	
				1" Deflection	2" Deflection
2.0	6.7	5.4	3.7	6.7	6.7
2.5	8.3	6.7	4.6	6.7	8.3
3.0	10.0	8.0	5.5	6.1	10.0
3.5	11.6	9.3	6.4	5.6	11.3
4.0	13.3	10.6	7.3	5.3	10.5
4.5	14.9	11.9	8.2	5.0	9.9
5.0	16.5	13.2	9.1	4.7	9.4
5.5	18.1	14.5	10.0	4.5	9.0
6.0	19.7	15.8	10.8	4.3	8.6

Abbreviations:
ksf = kips per square foot

Table 17. Wall 05.55L Bearing Resistance and Elastic Settlement

Effective Footing Width, B (feet)	Unfactored Bearing Resistance (ksf)	Extreme Event Limit State Bearing Resistance (ksf)	Strength Limit State Bearing Resistance (ksf)	Service Limit State Bearing Resistance (ksf)	
				1" Deflection	2" Deflection
3.0	38.2	30.5	21.0	5.7	11.3
4.0	45.2	36.2	24.9	4.9	9.8
50	52.2	41.8	28.7	4.4	8.8
6.0	59.2	47.4	32.6	4.0	8.0
7.0	66.2	52.9	36.4	3.7	7.4
8.0	73.0	58.4	40.2	3.5	6.9
9.0	79.9	63.9	43.9	3.3	6.5
10.0	86.7	69.4	47.7	3.1	6.2
11.0	93.5	74.8	51.4	3.0	5.9

Abbreviations:
ksf = kips per square foot

Table 18. Wall 05.85L-A Bearing Resistance and Elastic Settlement

Effective Footing Width, B (feet)	Unfactored Bearing Resistance (ksf)	Extreme Event Limit State Bearing Resistance (ksf)	Strength Limit State Bearing Resistance (ksf)	Service Limit State Bearing Resistance (ksf)	
				1" Deflection	2" Deflection
5.0	12.0	10.8	7.8	3.1	6.3
7.0	13.6	12.3	8.9	2.6	5.3
9.0	15.3	13.8	9.9	2.3	4.7
11.0	16.9	15.2	11.0	2.1	4.1
13.0	18.5	16.7	12.0	1.8	3.7
15.0	20.1	18.1	13.1	1.7	3.3
17.0	21.6	19.5	14.1	1.5	3.1
19.0	23.1	20.8	15.0	1.4	2.8
21.0	24.6	22.2	16.0	1.3	2.7
23.0	26.1	23.5	17.0	1.3	2.5
25.0	27.5	24.8	17.9	1.2	2.4

Abbreviations:
ksf = kips per square foot

Table 19. Wall 05.85L-B Bearing Resistance and Elastic Settlement

Effective Footing Width, B (feet)	Unfactored Bearing Resistance (ksf)	Extreme Event Limit State Bearing Resistance (ksf)	Strength Limit State Bearing Resistance (ksf)	Service Limit State Bearing Resistance (ksf)	
				1" Deflection	2" Deflection
5.0	17.8	16.0	11.6	2.1	4.2
7.0	20.2	18.2	13.1	1.8	3.6
9.0	22.6	20.3	14.7	1.6	3.1
11.0	24.9	22.4	16.2	1.4	2.8
13.0	27.3	24.5	17.7	1.3	2.6
15.0	29.6	26.6	19.2	1.2	2.4
17.0	31.9	28.7	20.7	1.1	2.3
19.0	34.2	30.8	22.2	1.1	2.2
21.0	36.5	32.9	23.7	1.0	2.1

Abbreviations:
ksf = kips per square foot

We evaluated the elastic settlement of placed fill on embankment EMB: I-405 SB MP 5.97 to 5.83. Based on our analyses, total settlement of the embankment is less than 1 inch, which meets the settlement criteria outline in RFP Chapter 2.6.6.7.

Bearing resistance and elastic settlement calculations are presented in Appendices C through G. Settle3 output reports are presented in Appendix H.

8.5 Seepage Analysis

We evaluated the groundwater levels at Wall 05.85L-A, Wall 05.85L-B, and embankment EMB: I-405 SB MP 5.97 to 5.83 by performing a seepage analysis at the design section at Wall 05.85L-A using measured piezometer data in borings H-2-85 and H-3-85.

We set hydraulic boundary conditions at the edges of the model to avoid influencing seepage results. In an attempt to match the groundwater measured in boring H-3-85, we used a constant head boundary condition equal to elevation 218 feet on the upslope edge of the model under I-405. We consider this boundary condition to be very conservative based on available groundwater data. We used a constant head boundary condition equal to elevation 160 feet on the downslope edge of the model to develop a phreatic surface similar to the measured groundwater level in boring H-2-85. We used a 2.6 x 10^{-7} feet per second flux boundary condition for surficial precipitation infiltration based on average rainfall of 8.1 inches per month in Renton, Washington in November (website: en.climate-data.org, accessed 4/9/2021), conservatively assuming all precipitation infiltrates.

We modeled each ESU encountered at Wall 05.85L-A (ESU 2A, ESU 2B, ESU 4B, and ESU 5B) with the following material properties:

- Saturated and unsaturated hydraulic properties to allow each material the potential for saturated and unsaturated flow;
- Saturated hydraulic conductivities estimated by using the Schlichter method for ESU 2A and ESU 2B and using recommended values from Laprade and Robinson, 1989 (see discussion in Section 7.1.6) for ESU 4B and ESU 5B;
- Volumetric water contents estimated from sample functions provided in Seep/W based on soil descriptions and saturated water content;
- Horizontal hydraulic conductivity functions estimated from the volumetric water content function using curve-fitting parameters from the Fredlund-Xing-Huang method; and
- Permeability anisotropy estimated by selecting the anisotropy ratio (vertical hydraulic conductivity to horizontal hydraulic conductivity). Anisotropy ratios are based on geologic setting, material composition, published values, and our engineering judgement.

To calibrate the seepage model, we used the saturated hydraulic conductivities and anisotropy ratios presented in Table 20.

Table 20. Saturated Hydraulic Conductivities and Anisotropy Ratios

ESU	Saturated Hydraulic Conductivity (feet/second)	Anisotropy Ratio, ky/kx
2A	1.1 x 10^{-4}	0.8
2B	3.3 x 10^{-5}	0.5
4B	3.8 x 10^{-7}	0.025
5B	3.8 x 10^{-8}	0.005

Abbreviations:
ESU = Engineering Stratigraphic Unit

We used the Seep/W model results in Slope/W to represent pore pressure distributions from the seepage analysis in the global stability analysis. By coupling the two analyses, we avoided overly conservative results that would have been obtained using a simple phreatic surface reflecting the higher measured groundwater in boring H-3-85 and potentially unconservative results that would have been obtained using a simple phreatic surface reflecting the deeper measured groundwater in boring H-2-85. Furthermore, this coupling approach cancels small negative pore pressures occurring at the base of the slices within the failure

surface, effectively maintaining a degree of conservatism in the stability analysis by not allowing increases in soil strength as a result of matric suction.

The steady-state seepage model is presented in Appendix E. The Seep/W output report is presented in Appendix I.

8.6 Global Stability

We evaluated global stability of Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 at the design sections presented in Table 1. Per Project GDM Section 15-4.12 and Section 6-4.3.2, a static resistance factor of 0.75 (FS = 1.3) and seismic resistance factor of 0.9 (FS = 1.1) shall be used for global stability of Walls 05.85L-A and 05.85L-B. Per Project GDM Section 15-4.12, a static resistance factor of 0.75 (FS = 1.3) shall be used for global stability of Wall 05.55L. Per Project GDM Section 9.2.3, a static resistance factor of 0.8 (FS = 1.25) shall be used for global stability of Grade Separation Barrier 05.33R and embankment EMB: I-405 SB MP 5.97 to 5.83 since they do not support or potentially impact structures.

Per AASHTO LRFD Section 11.10.2.2, we modeled a 4-foot horizontal bench in front of Walls 05.55L, 05.85L-A, and 05.85L-B. Based on preliminary drawings from Wood received on November 11, 2021, we modeled a 2-foot embedment at Wall 05.55L. We modeled the front face embedment depth as 3 feet and 3.5 feet for Walls 05.85L-A and 05.85L-B, respectively, using criteria outlined in AASHTO LRFD Table C11.10.2.2-1. For Wall 05.85L-B, the embedment depth was based on the slope from the front of the horizontal bench to the existing ground surface.

We initially evaluated global stability using a minimum reinforcement length of 70 percent of the overall wall height (0.7H) at Walls 05.85L-A and 05.85L-B. To meet the minimum FS for global stability, we increased the reinforcement length to 0.8H for Wall 05.85L-A. We modeled a 1.5-foot clearance backfilled with imported gravel borrow between the reinforced zone (back of the wall) and the face of the temporary shoring for Wall 05.85L-B and the bottom two rows at Wall 05.85L-A, and a 6-foot clearance backfilled with imported gravel borrow between the reinforced zone and the face of the temporary shoring for the upper six rows at Wall 05.85L-A. See Section 8.8.3 for discussion on temporary shoring.

We used the horizontal seismic coefficients, kh, for global stability presented in Table 8 for the pseudo-static analyses at Walls 05.85L-A and 05.85L-B. We applied the apparent cohesion values presented in Tables 5 and 6 in the pseudo-static analyses at Walls 05.85L-A and 05.85L-B, respectively. We used 50 psf apparent cohesion in the common borrow backfill behind Wall 05.85L-B for the pseudo-static analyses; see Section 8.7 below for a discussion on apparent cohesion in common borrow at Wall 05.85L-B. We used the residual shear strength presented in Table 5 for liquefiable soils to evaluate post-seismic global stability at Wall 05.85L-A.

Groundwater levels were modeled using a piezometric surface based on measured or observed groundwater levels at Grade Separation Barrier 05.33R and Wall 05.55L, and the seepage analysis to model the piezometric surface at Walls 05.85L-A and 05.85L-B, and embankment EMB: I-405 SB MP 5.97 to 5.83, as discussed in Section 5.3.

Per Project GDM Section 15-4.12, static, non-structural loads (such as traffic surcharge) shall be evaluated with a load factor of 1.0. For the static stability analysis, we applied a uniform traffic surcharge of 250 psf to Walls 05.55L, 05.85L-A, and 05.85L-B, and embankment EMB: I-405 SB MP 5.97 to 5.83. Per AASHTO LRFD Section 3.4.1, a load factor of 0.5 shall be applied to the traffic surcharge during the design seismic event. A uniform traffic surcharge of 125 psf was included for the seismic (pseudo-static and post-seismic) global stability analyses at Walls 05.55L, 05.85L-A, and 05.85L-B. A traffic surcharge was not included in our analysis of Grade Separation Barrier 05.33R since a roadway is not present above the barrier.

Where applicable, the required minimum static, pseudo-static, and post-seismic FSs were met for the walls, barrier, and embankment. Per the RFU geotechnical letter “Design Requirements and Geotechnical Assessment of Retaining Walls” (Hart Crowser, 2021), a seismic analysis is not required for Wall 05.55L since failure of the wall would not impact the travel lanes. Per Project GDM Section 9.2.3, seismic analyses are not required for global stability of the Grade Separation Barrier 05.33R or embankment EMB: I-405 SB MP 5.97 to 5.83 since neither support or would potentially impact structures.

We also evaluated the global stability of Walls 05.85L-A and 05.85L-B considering forward compatible walls for future I-405 widening. We modeled the forward compatible walls directly above Walls 05.85L-A and 05.85L-B with the face of the forward compatible wall set back 7 feet from the face of the proposed walls. For our analyses, we modeled the forward compatible wall as a high strength material with a unit weight of 130 pcf, a height extending from the top of the proposed walls

to the existing grade of I-405, and the width as 8 feet. We modeled the backfill behind the forward compatible wall as lightweight EPS using the strength properties presented in Table 7. Per RFP Section 1-01.3(1), forward compatible is defined as "project elements that are constructed so they can be integrated into the future configuration…without significant demolition or reconstruction of the Project Elements". To meet the requirements outlined in the RFP, we truncated the EPS behind the forward compatible walls at 4 feet from the proposed edge of the traveled way for the current project. The required minimum static, pseudo-static, and post-seismic FSs were met for all forward compatible wall cases.

Structural loads were not included in our analyses. Any structural foundation loads applied to the barrier, walls, or embankment shall include the appropriate load factors in AASHTO LRFD Table 3.4.1-1 consistent with Strength Limit State and Extreme Event Limit State design.

The results of our global stability analyses for Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and embankment EMB: I-405 SB MP 5.97 to 5.83 are summarized in Table 21. Global stability models showing FS for critical failures at the design sections are provided in Appendices C through G. Global stability Slope/W reports are provided in Appendix J.

Table 21. Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and Embankment EMB: I-405 SB MP 5.97 to 5.83 Global Stability Results

Design Element (Design Section)	Loading Type	Minimum Required Factor of Safety	Calculated Factor of Safety (Spencer/ Morgenstern-Price)	Minimum Reinforcement Length	Minimum Wall Embedment
Grade Separation Barrier 05.33R (Sta. 1+58)	Static	1.25	1.69 / 1.69	Not Applicable	Not Applicable
Wall 05.55L (Sta. 1+50)	Static	1.3	2.5 / 2.5	Not Applicable	2 feet
Wall 05.85L-A (Sta. 1+90)	Static	1.3	1.6 / 1.6 (FC: 1.7 / 1.7)	0.8H (upper 6 rows) 1.0H (bottom 2 rows)	3 feet
	Pseudo-Static	1.1	1.2 / 1.2 (FC: 1.3 / 1.3)		
	Post-Seismic	1.1	1.6 / 1.6 (FC: 1.7 / 1.7)		
Wall 05.85L-B (Sta. 2+60)	Static	1.3	1.4 / 1.4 (FC: 1.5 / 1.5)	0.7H	3.5 feet
	Pseudo-Static	1.1	1.3 / 1.3 (FC: 1.3 / 1.3)		
Embankment EMB: I-405 SB MP 5.97 to 5.83 (MP 5.88)	Static	1.25	1.28 / 1.27	Not Applicable	Not Applicable

Abbreviations:
FC = Forward Compatible
H = Height of the wall (exposed face and embedded depth), in feet
MP = Mile Post
Sta. = Station

8.7 Compound Stability

We used the results of the global stability analyses to model and evaluate compound stability of Walls 05.85L-A and 05.85L-B at the design sections presented in Table 1. Per Project GDM Section 15-4.12 and Section 6-4.3.2, a static resistance factor of 0.75 (FS = 1.3) and seismic resistance factor of 0.9 (FS = 1.1) shall be used for compound stability.

We used the horizontal seismic coefficients, kh, for compound stability presented in Table 8 for the pseudo-static analyses at Walls 05.85L-A and 05.85L-B. We applied the apparent cohesion values presented in Tables 5 and 6 for the native soils in the pseudo-static analyses at Walls 05.85L-A and 05.85L-B, respectively. To meet minimum FSs for the pseudo-static analysis at Wall 05.85L-B, we modeled the common borrow backfill with 50 psf apparent cohesion. Per FHWA Geotechnical Engineering Circular No. 3 Table 11-2, 50 psf apparent cohesion should be assumed for a backfill soil with a fines content between 5 and 15 percent by weight. Per the soil plasticity table presented in WSDOT Standard Specification 9-03.14(3), Option 2 common borrow contains 12.1 to 35 percent fines content by weight. The common borrow imported during construction shall be Option 2, as specified in Section 8.13.1.

We used the residual shear strength presented in Table 5 for liquefiable soils to evaluate post-seismic compound stability at Wall 05.85L-A.

Per Project GDM Section 15-5.3.4 and AASHTO LRFD Table 3.4.1-1, a strength limit state load factor of 1.75 shall be applied to the standard traffic surcharge of 250 psf directly over the reinforced zone. For the static stability analysis, we applied a uniform traffic surcharge of 437.5 psf directly over the reinforced zone and a uniform traffic surcharge of 250 psf outside of the reinforced zone to Walls 05.85L-A and 05.85L-B. Per AASHTO LRFD Section 3.4.1, an extreme event limit state load factor of 0.5 shall be applied to the standard traffic surcharge of 250 psf during the design seismic event. A uniform traffic surcharge of 125 psf was included across all traffic lanes (both directly over and outside of the reinforced zone) for the seismic (pseudo-static and post-seismic) compound stability analyses at Walls 05.85L-A and 05.85L-B.

Groundwater levels for Walls 05.85L-A and 05.85L-B were modeled using the piezometric surface from the seepage analysis at Wall 05.85L-A, as discussed in Section 5.3.

We evaluated compound stability using the minimum reinforcement lengths required to meet the minimum FSs from the global stability analyses. For compound stability of Wall 05.85L-A, we modeled 8 rows of reinforcing strips (2 strips per row in each facing panel) at a length of 0.8H. We set the horizontal spacing of the reinforcing strips at 2.5 feet, and the vertical spacing of the upper 7 rows at 2.4 feet, with the bottom row at 1.7 feet above the bottom of the leveling pad. For compound stability of Wall 05.85L-B, we modeled 10 rows of reinforcing strips at a length of 0.7H. We set the horizontal spacing of the reinforcing strips at 2.5 feet, and the vertical spacing of the upper 9 rows at 2.4 feet, with the bottom row at 0.5 feet above the bottom of the leveling pad.

The required minimum static and pseudo-static FSs were met for proposed Wall 05.85L-B. To meet the minimum static and seismic (pseudo-static and post-seismic) FSs for proposed Wall 05.85L-A, we increased the reinforcing strips to a length of 1.0H with 4 strips in each of the bottom 2 rows and decreased the horizontal spacing to 1.25 feet.

We also evaluated the compound stability of Walls 05.85L-A and 05.85L-B considering forward compatible walls for future I-405 widening. We used the same geometry and strength properties from the global stability analyses to model the forward compatible walls in the compound stability analyses. To meet required compound stability minimum FSs for the forward compatible wall cases at Walls 05.85L-A and 05.85L-B, we modeled the forward compatible walls as a simple block with a set width and set unit weight and the backfill as lightweight EPS. Another option to meet required compound stability minimum FSs would be to optimize the design of the forward compatible walls. We did not explore all potential options as design of the forward compatible walls is outside the scope of this project, however, we have demonstrated that walls for future I-405 widening projects can be designed and constructed without demolition or reconstruction of Walls 05.85L-A and 05.85L-B.

Structural loads were not included in our analyses. Any structural foundation loads applied to Walls 05.85L-A and 05.85L-B shall include the appropriate load factors in AASHTO LRFD Table 3.4.1-1 consistent with Strength Limit State and Extreme Event Limit State design.

The results of our compound stability analyses for Walls 05.85L-A and 05.85L-B are summarized in Table 22. Compound stability models showing FS for critical failures at the design sections are provided in Appendices E and F. Compound stability Slope/W reports are provided in Appendix K.

Table 22. Walls 05.85L-A and 05.85L-B Compound Stability Results

Wall (Design Section)	Loading Type	Minimum Required Factor of Safety	Calculated Factor of Safety (Spencer/ Morgenstern-Price)	Minimum Reinforcing Strip Length/ Number of Reinforcement Rows
05.85L-A (Sta. 1+90)	Static	1.3	1.3 / 1.3 (FC: 1.3 / 1.3)	0.8H / upper 6 rows 1.0H / bottom 2 rows
	Pseudo-Static	1.1	1.1 / 1.1 (FC: 1.1 / 1.1)	
	Post-Seismic	1.1	1.3 / 1.3 (FC: 1.4 / 1.4)	
05.85L-B (Sta. 2+60)	Static	1.3	1.4 / 1.4 (FC: 1.4 / 1.5)	0.7H / 10 rows
	Pseudo-Static	1.1	1.1 / 1.1 (FC: 1.3 / 1.3)	

Abbreviations:
FC = Forward Compatible
H = Height of the wall (exposed face and embedded depth), in feet
Sta. = Station

8.8 Structural Earth Wall (SEW) Fill Material Properties, Drainage, and Temporary Shoring Recommendations

8.8.1 SEW Soil Parameters

Internal stability of Walls 05.85L-A and 05.85L-B will be evaluated by the design-build team's wall designers and submitted under separate cover. We developed geotechnical properties for the reinforced zone fill in the SEW, the retained fill behind the SEW, and the foundation soil below the SEW to support the internal design calculations. SEW soil parameter recommendations are presented in Table 23.

Table 23. Walls 05.85L-A and 05.85L-B SEW Soil Parameter Recommendations

SEW Soil Recommendations	
Reinforced Zone Fill	**Gravel Borrow for Structural Earth Wall WSDOT Standard Specification 9-03.14(4)**
Unit Weight (pcf)	130
Friction Angle (degrees)	38
Cohesion (psf)	0

SEW Soil Recommendations		
Retained Fill	**Gravel Backfill for Walls WSDOT Standard Specification 9-03.12(2)**	
Unit Weight (pcf)	130	
Friction Angle (degrees)	38	
Cohesion (psf)	0	
Foundation Soil	**Wall 05.85L-A ESU 2A**	**Wall 05.85L-B ESU 2B**
Unit Weight (pcf)	110	115
Friction Angle (degrees)	32	34
Cohesion (psf)	0	0

Abbreviations:
ESU = Engineering Stratigraphic Unit
WSDOT = Washington State Department of Transportation
pcf = pounds per cubic foot
psf = pounds per square foot
ESU = Engineering Stratigraphic Unit

8.8.2 SEW Drainage

The SEWs shall be designed and constructed with a permanent drainage system. The surface drainage system shall intercept surface water at the top of the SEW to prevent sheet flow across the wall face and reduce infiltration and groundwater buildup in the reinforced zone. Gutters shall be installed behind the wall to intercept surface water and convey it to an appropriate discharge point. Where possible, the ground surface adjacent to the wall shall be sloped such that water is diverted away from the wall toe.

Positive drainage shall consist of placing a minimum 18-inch-wide zone of free draining gravel backfill immediately behind the SEW zone. Drainage material shall consist of WSDOT Standard Specification is Section 9-03.12(2), Gravel Backfill for Walls. A 4-inch minimum diameter perforated drainpipe shall be embedded in the drainage layer and routed to an appropriate discharge location.

8.8.3 Temporary Shoring

Since the proposed locations of the SEWs are adjacent to and below I-405 and temporary excavations would intersect the roadway, temporary shoring will be required prior to constructing Walls 05.85L-A and 05.85L-B. For access and equipment during construction of the proposed SEWs, the shoring wall will need to be installed an adequate distance behind the back of the walls. The temporary shoring wall shall be designed for live traffic loads and appropriate surcharges, including soil slopes and construction traffic. Any groundwater or surface water encountered during shoring construction shall be dewatered following recommendations presented in Section 8.9.2.

8.9 Site Preparation and Earthwork

8.9.1 Earthwork Considerations

We anticipate that the site soils at each barrier or wall discussed in this geotechnical engineering report can be excavated with conventional excavation equipment, such as trackhoes or dozers. Excavations extending into glacially consolidated soils (ESU 4B and ESU 5B) may be difficult. Excavations may encounter debris, large cobbles, and boulders.

8.9.2 Dewatering

Based on our understanding of site conditions, we do not anticipate that excavations will extend below the seasonal high-water table. However, it is possible that perched groundwater seepage may be encountered during excavations at Walls 05.85L-A and

05.85L-B. Any groundwater seepage or surface water that cannot be handled successfully with sumps and pumps shall be routed away from the excavation areas to an appropriate location where it can be treated (if necessary) and discharged.

8.9.3 Bearing Surface Preparation

Bearing surfaces for the barrier and walls must be evaluated by GeoEngineers before installation of the barrier and wall foundations to identify loose, soft, or otherwise unsuitable soils. This evaluation shall be identified as a hold point on the relevant barrier and wall plans. If unsuitable soils are identified during evaluation, GeoEngineers will provide recommendations for remediation or repair of the unsuitable areas. Based on nearby borings, we expect to encounter the following ESUs at or near the foundation bearing elevations:

- Grade Separation Barrier 05.33R– ESU 1B
- Wall 05.55L – ESU 1B
- Wall 05.85L-A – ESU 2A
- Wall 05.85L-A – ESU 2B

8.10 Temporary Shoring

To facilitate construction of Walls 05.85L-A and 05.85L-B, a shoring wall will be required. Temporary shoring recommendations for Walls 05.85L-A and 05.85L-B are presented in Section 8.8.3.

8.11 Temporary Cut Slopes

Temporary cut slopes shall not exceed the maximum allowable inclinations presented in Project GDM Section 15-7.4.

8.12 Permanent Slopes

Permanent slopes shall be inclined no steeper than 2H:1V. Permanent slopes shall be planted or hydroseeded as soon as practicable after grading. Temporary erosion control measures, such as erosion control blankets, shall be incorporated until permanent vegetation and erosion control has been established.

8.13 Materials

8.13.1 Common Borrow

Common borrow shall conform to WSDOT Standard Specification 9-03.14(3) and, at specifically at Wall05.58L-B, shall consist of Option 2 for soil plasticity.

8.13.2 Select Borrow

Select borrow shall conform to WSDOT Standard Specification 9-03.14(2).

8.13.3 Gravel Borrow

Gravel borrow shall conform to WSDOT Standard Specification 9-03.14(1).

8.13.4 Gravel Borrow for Structural Earth Wall

Gravel borrow for structural earth wall shall conform to WSDOT Standard Specification 9-03.14(4) and Cu shall be 6.3 or greater.

8.13.5 Gravel Backfill for Walls

Gravel backfill for walls shall conform to WSDOT Standard Specification 9-03.12(2).

8.13.6 Crushed Surfacing Base Course

CSBC shall conform to WSDOT Standard Specification 9-03.9(3).

8.14 Fill Placement

Barrier and wall backfill and foundation subgrade shall be placed and compacted in accordance with Method C of Section 2-03.3(14)C of the WSDOT Standard Specifications.

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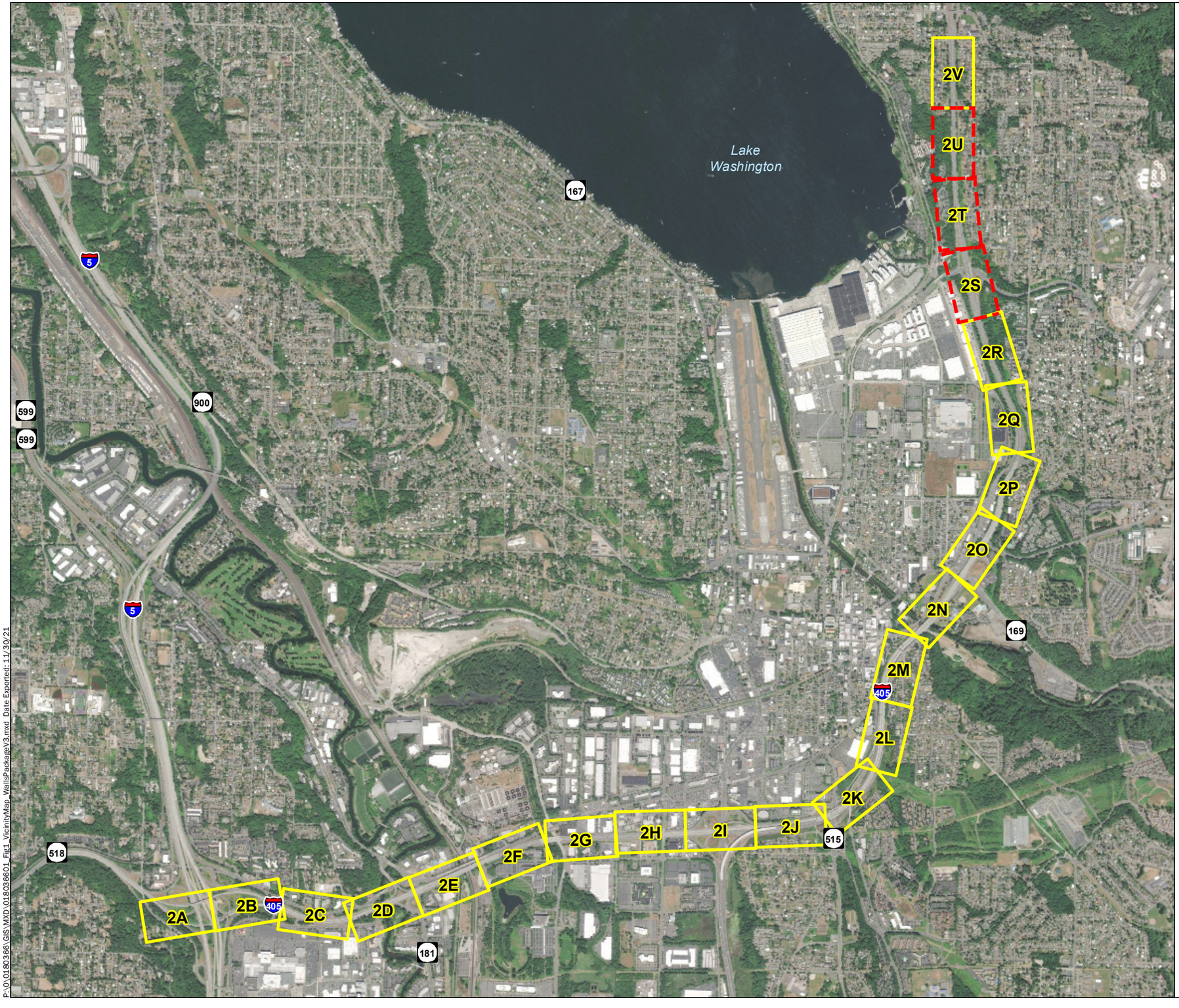

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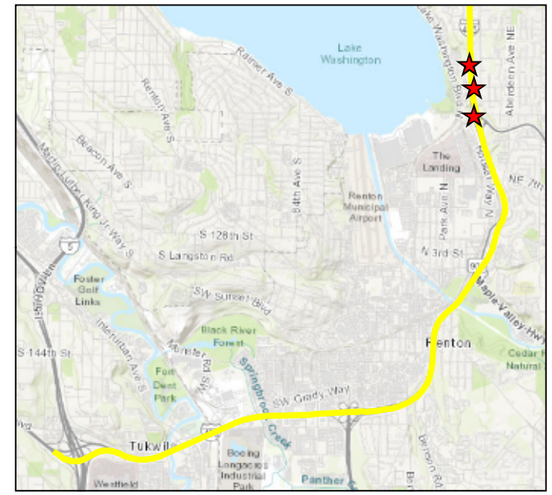
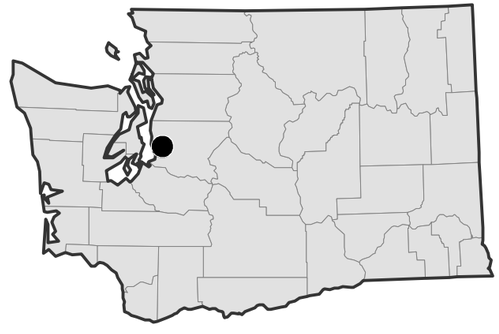
Legend

- Project Location
- Grade Separation Barrier 05.33R; Walls 05.55L, 05.85L-A, and 05.85L-B; and Embankment EMB: I-405 SB MP 5.97 to 5.83
- Segment 1A
- Site Plan Index
- Site Plan Index Sheets Included in this Report



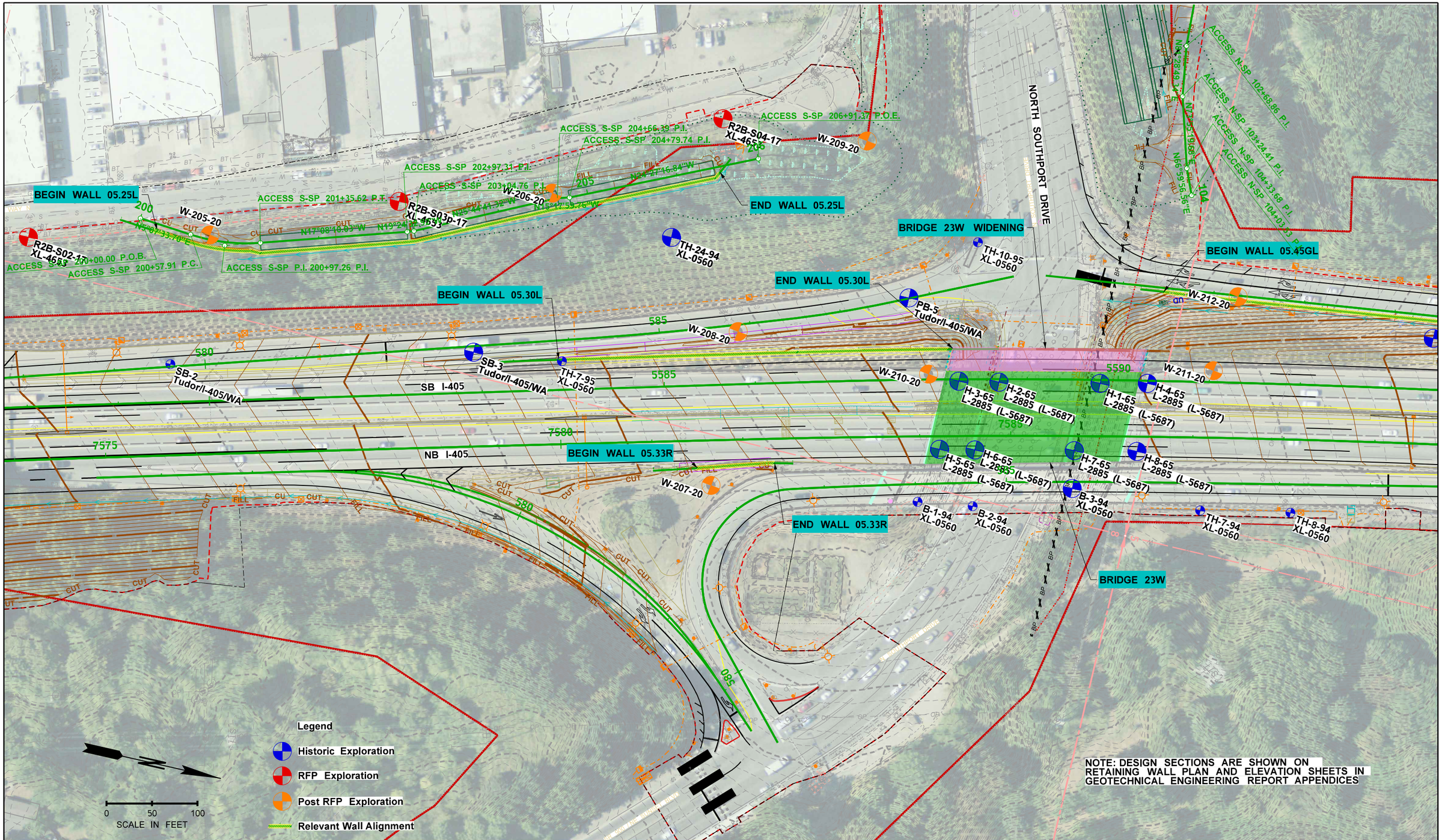


Vicinity Map

I-405 Renton to Bellevue
Segment 1A - Walls Package 2
King County, Washington

GeoEngineers

Figure 1



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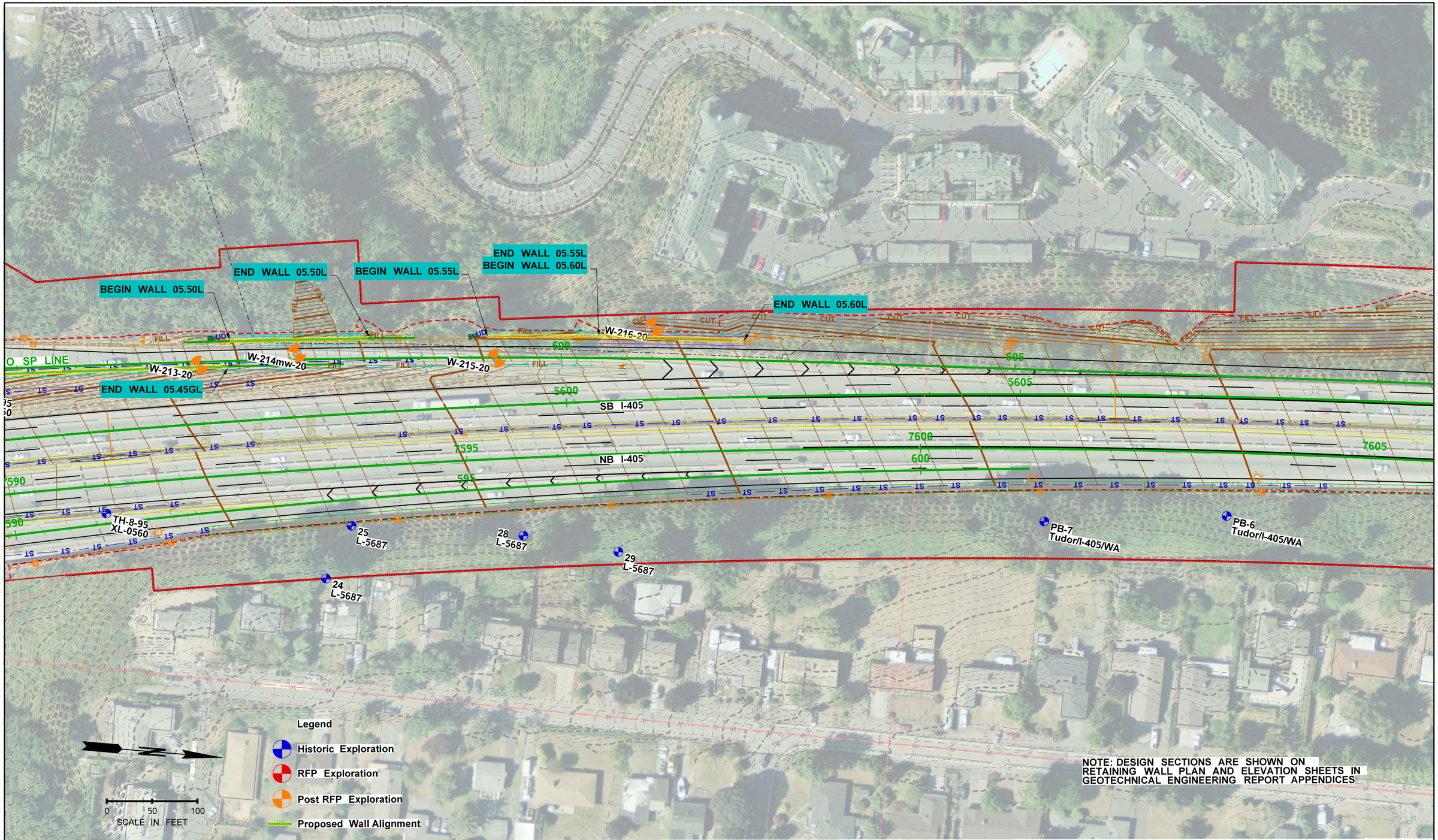

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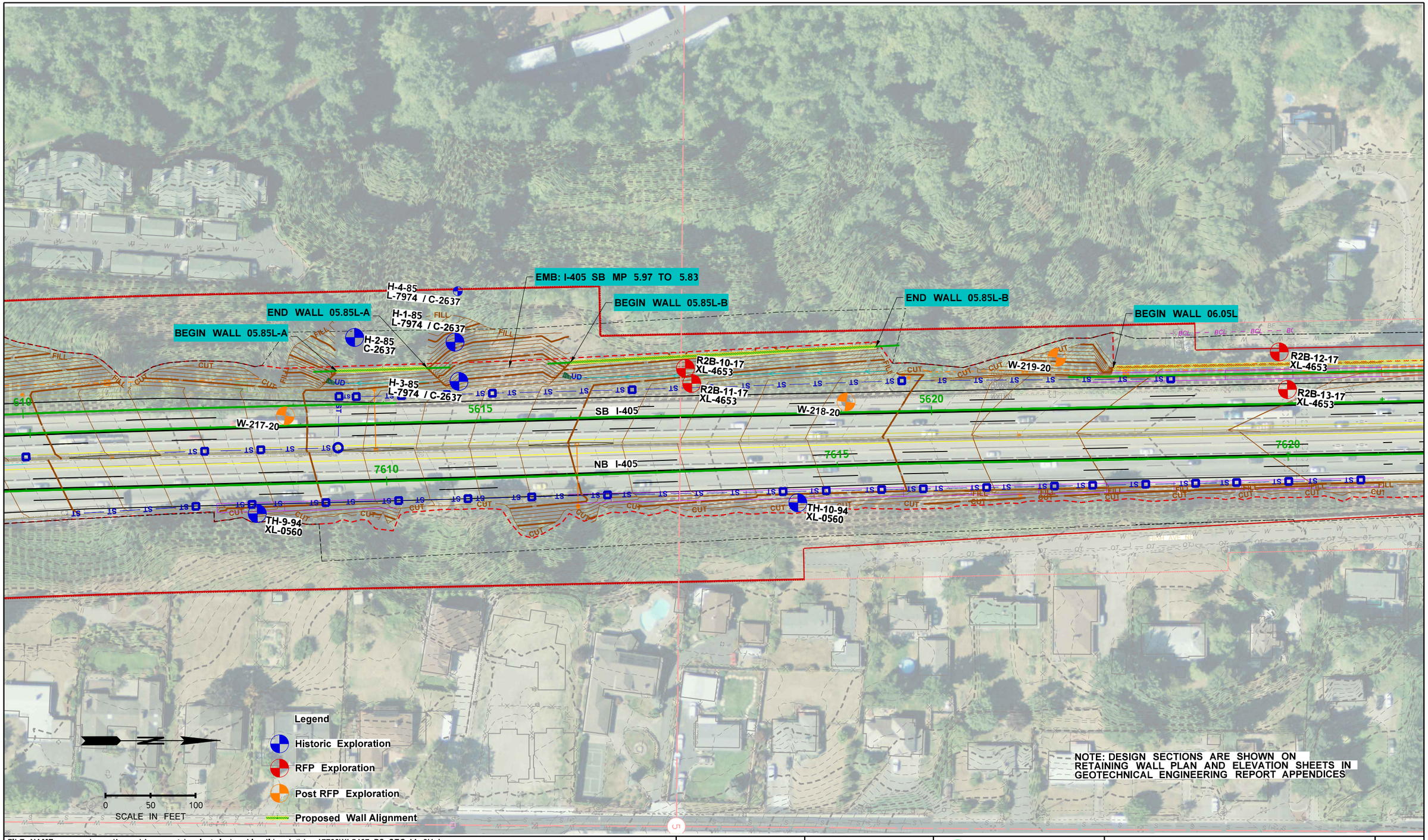

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN
FIGURE 2U

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In Association with

Appendix A
Field Exploration Logs

TABLE A-1
I-405 RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT
GEOLOGIC UNITS AND DESCRIPTIONS

Unit Name	Abbreviation	Unit Description
Quaternary Units		
Fill	Af	Fill placed by humans, both engineered and uncontrolled fill consisting of various materials, including debris; typically dense or stiff if engineered, but very loose to dense or very soft to stiff if uncontrolled fill.
Landslide Debris	Qls	Soil deposits associated with slope failures, mass wasting and mud flows of soils. Normally found at and adjacent to the toes of hillslopes or in drainage channels, consisting of disturbed, heterogeneous mixtures of all soil types and intermixed debris; loose or soft, with random dense to hard pockets.
Peat	Qp	Depression fillings of organic materials consisting of peat, peaty silt; peaty silty clay, peaty sandy silt, and organic silts and clays with sand; very soft to medium stiff.
Alluvium	Qal	Mainly river, creek or overbank deposits, consisting of sand, silty sand; gravelly sand and sandy gravel with scattered organics that are typically very loose to dense, and includes interbedded slack water or lake deposits that consist of silts, clays and sandy silts.
Recessional Deposits	Qvr	Sediments deposited after glacial ice retreated that have not been glacially overridden. These recessional deposits include: Outwash- glaciofluvial sediment deposited off the retreating glacier consisting of sand or silty sand; locally gravelly; loose to dense; Ablation Till- heterogeneous soils deposited during the wasting of glacial ice; generally not reworked consisting of gravelly, silty sand, gravelly, sandy silt or clayey silt; loose to dense or soft to very stiff; Ice Contact Deposits- heterogeneous soils deposited against or adjacent to ice during the wasting of glacial ice; commonly reworked, consisting of stratified to irregular bodies of gravel, sand and silt; loose to dense; and Lacustrine Deposits- sediments deposited as glacial ice retreated consisting of silt and clay; locally fine sand; soft to very stiff.
Vashon Glacial Till	Qvt	Lodgment till laid down along the base of the glacial ice and overridden by the weight of glacial ice, consisting of gravelly, silty sand or gravelly, sandy silt (“hardpan”); boulders and cobbles common; gray and very dense, and in its weathered state may be oxidized brown and medium dense to dense. Sometimes referred to as a diamicton.
Advance Outwash	Qva	Glaciofluvial sediment deposited as the glacial ice advanced through the Puget Lowland and overridden by the weight of glacial ice; typically stratified, light brown to gray, sand, gravelly sand, and sandy gravel; dense to very dense.
Proglacial Lacustrine Deposits (Lawton Clay)	Qgl	Fine-grained glacial sediment deposited in pro-glacial lake in Puget Lowland consisting of interbedded brown, gray to blue-gray silt, clayey silt; silty clay; fine sand; massive to locally laminated or locally disturbed (fractures and slickensides); scattered wood near base; very stiff to hard or dense to very dense.
Pre-Fraser Deposits	Qpf	Undifferentiated interbedded gravel, sands and silts; typically, oxidized orange or reddish brown, dense to very dense.
Tertiary Formations		
Intrusive Andesite	Oian	Igneous bedrock consisting mainly of andesite.
Renton Formation	Tr	Sedimentary bedrock; tan friable silty sandstone, siltstone with interbedded coal seams.

Field Soil Description

wood.

ORDER OF CLASSIFICATION TERMS

1. Soil classification
2. Relative density/consistency
3. Color (based on Munsell Color Chart)
4. Moisture
5. Structure
6. Other - plasticity, dilatancy, organics, odor

Geologic Name: Fill, Glacial Till, etc. (optional - ask project manager)

EXAMPLES

Well graded GRAVEL, with cobbles and boulders, subrounded, medium dense, grayish brown, wet, homogeneous, no HCL reaction or HCL not tested (Alluvium) SM

Silty fine SAND with gravel, prevalent roots and fine organics, subrounded, loose, brownish black, moist, no HCL reaction or HCL not tested (Relict Topsoil) SM

Fibrous or amorphous PEAT with or without some silt/clay; PT

Fat CLAY with sand, medium stiff, dark gray, wet, blocky, no HCL reaction or HCL not tested (Lawton Clay) CH

RELATIVE DENSITY OF GRANULAR SOILS (Cohesionless Silt, Sand, and Gravel)

N, SPT, BLOWS/FT	RELATIVE DENSITY	FIELD TEST FOR RELATIVE DENSITY OF SAND*
0-4	Very loose	Penetrated 3 feet or more by hand probe
4-10	Loose	Penetrated 1 to 2 feet by hand probe
11-24	Med-dense	Penetrated 3 to 12 inches by hand probe
25-50	Dense	Penetrated 1 to 3 inches by hand probe
Over 50	Very Dense	Penetrated less than 1 inch by hand probe * varies with soil type

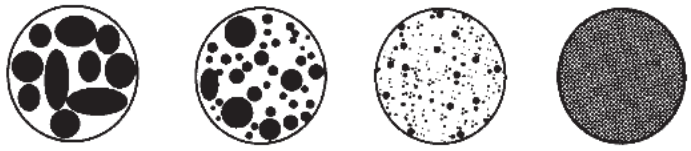
RELATIVE CONSISTENCY OF COHESIVE SOILS (Cohesive, Silt, and Clay)

N, SPT, BLOWS/FT	RELATIVE DENSITY	TORVANE, tsf SHEAR STR.	POC. PEN., tsf UNCONF. STR.	MANUAL PENETRATION TEST
0-1	Very soft	<0.13	<0.25	Easy several inches by fist
2-4	Soft	0.13 - 0.25	0.25 - 0.5	Easy several inches by thumb
5-8	Medium stiff	0.25 - 0.5	0.5 - 1	Moderate several inches by thumb
9-15	Stiff	0.5 - 1	1 - 2	Readily indented by thumb
16-30	Very stiff	1 - 2	2 - 4	Readily Indented by thumbnail
30-60	Hard	>2	>4	Difficulty by thumbnail

SOIL STRUCTURE

Stratified	Alternating layers of varying material or color with layers at least 6mm (1/4") thick
Laminated	Alternating layers of varying material or color with layers less than 6 mm (1/4") thick
Seam	2 to 13 mm (1/16" - 1/2") thick
Layer	13 to 305 mm (1/2" - 12") thick
Occasional	One or less per foot of thickness
Frequent	More than one per foot of thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear to be polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, generally discontinuous, such as small lenses of sand through out a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout

GRAIN SIZE



Coarse Sand | Medium Sand | Fine Sand | Fine <#200

UNIFIED SOIL CLASSIFICATION SYSTEM (From ASTM D-2488 & 2487-90)

MAJOR DIVISIONS			GROUP SYMBOL	TYPICAL DESCRIPTION
Coarse-Grained Soils (more than 50% retained on No. 200 sieve)	Gravels (more than 50% of coarse fraction retained on No. 4 sieve)	Clean Gravels (less than 10% fines)	GW	Well-Graded Gravels, Gravel-Sand Mixtures, Little or No Fines
			GP	Poorly-Graded Gravels, Gravel-Sand Mixutres
		Gravels with Fines (>10% fines)	GM	Silty Gravels, Gravel-Sand-Silt Mixtures
			GC	Clayey Gravels, Gravel-Sand-Clay Mixtures
	Sands (50% or more of coarse fraction passes the No. 4 sieve)	Clean Sands (<10% fines)	SW	Well-Graded Sands, Gravelly Sands, Little or No Fines
			SP	Poorly-Graded Sand, Gravelly Sands, Little or No Fines
		Sands with Fines (>10% fines)	SM	Silty Sands, Sand-Silt Mixtures
			SC	Clayey Sands, Sand-Clay Mixtures
Fine-Grained Soils (50% or more passes the No. 200 sieve)	Silts and Clays (liquid limit less than 50)	Inorganic	ML	Inorganic silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands or Clayey Silts with Slight Plasticity
			CL	Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
		Organic	OL	Organic Silts and Organic Silty Clays of Low Plasticity
	Silts and Clays (liquid limit 50 or more)	Inorganic	CH	Inorganic Clays of Medium to High Plasticity, Sandy Fat Clay, Gravelly Fat Clay
			MH	Inorganic Silts, Micaceous or Diatomaceous Fine Sands or Silty Soils, Elastic Silt
		Organic	OH	Organic Clays of Medium to High Plasticity, Organic Silts
Highly Organic Soils	Primarily organic matter, dark in color, and organic ordor		PT	Peat, Humus, Swamp Soils with High Organic Content (See D 4427-92)

MOISTURE CONTENT

Dry - Dusty, dry to touch

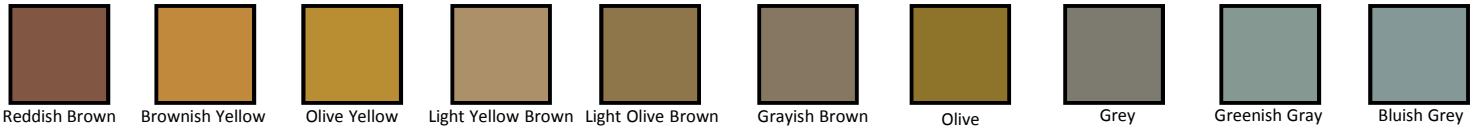
Moist - Damp but no visible water

Wet - Visible free water

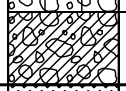
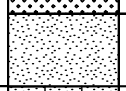
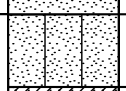
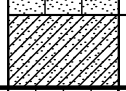
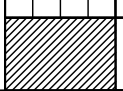
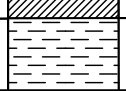
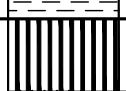
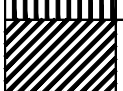
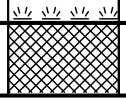
ORGANIC CONTENT

ADJECTIVE	PERCENT BY VOLUME
Scattered	1 - 10
Numerous	10 - 30
Organic	30 - 50 minor constituent
PEAT	50 - 100 MAJOR constituent
Describe type and size of organic debris	

MUNSELL COLORS:



Reddish Brown | Brownish Yellow | Olive Yellow | Light Yellow Brown | Light Olive Brown | Grayish Brown | Olive | Grey | Greenish Gray | Bluish Grey

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE)	GRAVEL AND GRAVELLY SOILS (MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE)	CLEAN GRAVELS (LESS THAN 5% FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (GREATER THAN 12% FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS (MORE THAN 50 OF COARSE FRACTION PASSING NO. 4 SIEVE)	CLEAN SANDS (LESS THAN 5% FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (GREATER THAN 12% FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS (MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE)	SILTS AND CLAYS (LIQUID LIMIT LESS THAN 50)	INORGANIC		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
		ORGANIC		OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (LIQUID LIMIT GREATER THAN 50)	INORGANIC		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
		ORGANIC		OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS
FILL SOILS				FILL (AF)	HUMAN ALTERED SOIL OR MODIFIED LAND

NOTES:

1. SOIL DESCRIPTIONS ARE BASED ON THE GENERAL APPROACH PRESENTED IN THE STANDARD PRACTICE FOR DESCRIPTION AND IDENTIFICATION OF SOILS (VISUAL-MANUAL PROCEDURE), AS OUTLINED IN ASTM D 2488. WHERE LABORATORY INDEX TESTING HAS BEEN CONDUCTED, SOIL CLASSIFICATIONS ARE BASED ON THE STANDARD TEST METHOD FOR CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES, AS OUTLINED IN ASTM D 2487.

2. SOIL DESCRIPTION TERMINOLOGY IS BASED ON VISUAL ESTIMATES (IN THE ABSENCE OF LABORATORY TEST DATA) OF THE PERCENTAGES OF EACH SOIL TYPE AND IS DEFINED AS DESCRIBED BELOW:

3. DUAL SYMBOLS (E.G. SP-SM, OR GP-GM) ARE USED TO INDICATE A SOIL WITH AN ESTIMATED 5-12% FINES.

   PRIMARY CONSTITUENT: >50% - "GRAVEL", "SAND", "SILT", "CLAY", etc.
   SECONDARY CONSTITUENTS: >12% and ≤50% - "gravelly", "sandy", "silty", etc.
   ADDITIONAL CONSTITUENTS: >5% and ≤12% - "some gravel", "some sand", "some silt", etc.
   ≤5% - "trace gravel", "trace sand", "trace silt" etc. or not noted.

4. RELATIVE DENSITY OF SOIL IS BASED ON STANDARD TEST METHOD FOR PENETRATION TEST (SPT) AND SPLIT-BARREL SAMPLING OF SOILS ASTM D 1586 OR CORRELATIONS FOR OTHER SIMPLER TYPES AND METHODS FOR SPT SAMPLING, THE FOLLOWING BLOW COUNT CORRELATION APPLIES.

   A. RELATIVE DENSITY OF COARSE GRAINED SOILS (N = BLOWS/FOOT SPT METHOD)
   - VERY LOOSE: N = ≤4
   - LOOSE: N = >4 AND ≤10
   - MEDIUM DENSE: N = >10 AND ≤30
   - DENSE: N = >30 AND ≤50
   - VERY DENSE: N = >50

   B. RELATIVE CONSISTENCY OF FINE GRAINED SOILS (N = BLOWS/FOOT SPT METHOD)
   - VERY SOFT: N = <2
   - SOFT: N = ≥2 AND ≤4
   - MEDIUM STIFF: N = >4 AND ≤8
   - STIFF: N = >8 AND ≤15
   - VERY STIFF: N = >15 AND ≤30
   - HARD: N = >30

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4020 Lake Washington Blvd. NE, Suite 200
Kirkland, Washington 98033

wood.

SOIL CLASSIFICATION CHART / KEY

DATE: JUNE 2018
SCALE: NOT TO SCALE
PROJECT NO.
FIGURE: A-1

DRAWN BY: JRS CHECKED BY: JD

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Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-207-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

DATE STARTED 7/30/20 **COMPLETED** 7/30/20 **GROUND ELEVATION** 128.2 ft NAVD88 **HOLE SIZE** 8 inches

DRILLING CONTRACTOR Holt Services **DRILL RIG** Mobile B-57 ID#10 **SPT HAMMER EFFICIENCY** 87%

DRILLING METHOD HSA **STATION (FT)** 5585+47.74 **OFFSET (FT)** 109.4 R

LOGGED BY Patricia Reed **CHECKED BY** Bill Lockard **NORTHING** 186017.629 **EASTING** 1303588.587

NOTES **GW LEVEL (ATD)** Dry

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE / PL MC LL / FINES CONTENT (%)	TESTS AND REMARKS
0		Grass (8 inches) over				
		Silty SAND, medium dense, grayish brown, dry, [FILL] (SM)				
125		No recovery	0	SPT-1 12 12 11	23	
5			83	SPT-2 2 16 21	37	MC = 11% Fines = 37% Rock in barrel, SPT values may be overstated
120			11	SPT-3 6 8 10	18	MC = 13%
10		Becomes with gravel and scattered bits of clear glass	11	SPT-4 5 6 6	12	MC = 10% Fines = 31%
115		Sandy lean CLAY with gravel, soft, grayish brown, wet, dilatant with scattered fragments of coal, [FILL] (CL)				
15			83	SPT-5 1 1 1	2	MC = 17% LL = 28 PL = 20 Fines = 50%
		Construction DEBRIS; coal, brick, plaster, burnt wood within a CLAY matrix, [FILL] (CL)		ST-1		Shelby tube likely contains demolition debris, rock stuck in lower end
110						
20						

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PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-207-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐	TESTS AND REMARKS
20		Construction DEBRIS; coal, brick, plaster, burnt wood within a CLAY matrix, [FILL] (CL) *(continued)*	44	SPT-6 2 1 2	▲ 3	
105						
25			72	SPT-7 2 1 1	▲ 2	
100						
30		Silty SAND, dense, yellowish brown to grayish brown, moist, oxidized in places, stratified, disturbed, [Qvt] (SM)	94	SPT-8 1 9 20	● ☐▲ 29	MC = 14% Fines = 28%
95						
35		Becomes very dense	100	SPT-9 20 16 50/5"	50/5"	
90						
40			100	SPT-10 18 40 50/4"	50/4"	

Bottom of borehole at 41.4 feet.

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PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-215-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

DATE STARTED 7/27/20 **COMPLETED** 7/28/20 **GROUND ELEVATION** 171.2 ft NAVD88 **HOLE SIZE** 8 inches

DRILLING CONTRACTOR Holt Services **DRILL RIG** Mobile B-57 **SPT HAMMER EFFICIENCY** 87%

DRILLING METHOD HSA **STATION (FT)** 5599+25.14 **OFFSET (FT)** 52.4 L

LOGGED BY Patricia Reed **CHECKED BY** Bill Lockard **NORTHING** 187332.8835 **EASTING** 1303168.587

NOTES **GW LEVEL (ATD)** 31.0 ft / Elev 140.2 ft

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE / PL MC LL / FINES CONTENT (%)	TESTS AND REMARKS
0		ASPHALT (14 inches) over				
170		Silty SAND with gravel, dense, light gray, dry, [FILL] (SM)				
			78	SPT-1 9 25 21	▲ 46	MC = 10% Fines = 30%
5		gravel grades out	100	SPT-2 6 13 19	▲ 32	
165		Silty SAND, dense, light olive yellow, moist, [FILL] (SM)	78	SPT-3 5 15 17	● □ ▲ 32	MC = 15% Fines = 23%
10			100	SPT-4 6 18 21	▲ 39	
160						
15			100	SPT-5 3 10 13	▲ 23	
155		SILT with sand, dense, light olive yellow, moist, [Qvt] (ML)			● ⊡	MC = 19% LL = NP PL = NP Fines = 72%
20						

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PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-215-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE / PL MC LL / FINES CONTENT (%)	TESTS AND REMARKS
20		Silty SAND, very dense, light olive yellow, moist, [Qvt] (SM)	78	SPT-6 4 16 35	▲ 51	
150						
25			94	SPT-7 6 16 18	▲ 34	MC = 18% Fines = 23%
145						
30		SILT, dense, light olive yellow, wet, stratified with silty sand, [Qvt] (ML)	67	SPT-8 8 13 18	▲ 31	
140						

Bottom of borehole at 31.5 feet.

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PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-217-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

DATE STARTED 7/29/20 **COMPLETED** 7/30/20 **GROUND ELEVATION** 219.6 ft NAVD88 **HOLE SIZE** 8 inches

DRILLING CONTRACTOR Gregory Drilling **DRILL RIG** CME 55 ID: #310 **SPT HAMMER EFFICIENCY** 88%

DRILLING METHOD HSA **STATION (FT)** 5612+83.44 **OFFSET (FT)** 11.0 L

LOGGED BY Carlos Mendoza **CHECKED BY** Pat Reed **NORTHING** 188693.428 **EASTING** 1303110.552

NOTES **GW LEVEL (ATD)** Dry

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE / PL MC LL / FINES CONTENT (%)	TESTS AND REMARKS
0		ASPHALT (18 inches) over				
		Well graded SAND with gravel, olive yellow, subangular gravel, [FILL/Crushed rock base coarse] (SW)				
		Silty SAND, very dense, light olive brown, dry, subrounded gravel, [Qvt] (SM)	67	SPT-1 14 43 50	▲ 93	MC = 8% Fines = 45%
215 / 5		Silty SAND with gravel, very dense, light yellow brown, dry, subrounded gravel, [Qvt] (SM)	67	SPT-2 10 28 35	▲ 63	
		Silty SAND, very dense, bluish gray, moist, oxidation stains, [Qvt] (SM)	63	SPT-3 17 36 50/4"	50/4"	MC = 9% Fines = 37%
210 / 10		Becomes bluish gray	67	SPT-4 15 50	50/6"	
205 / 15			67	SPT-5 15 50	50/6"	MC = 12% Fines = 40%
200 / 20						

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PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-217-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE / PL MC LL / FINES CONTENT (%)	TESTS AND REMARKS
20		Silty SAND, very dense, bluish gray, moist, [Qvt] (SM)	63	SPT-6 30 50/2"	50/2"	
		SILT, very dense, gray, dry, [Qgl] (ML)				
195 / 25			44	SPT-7 4 27 24	51	MC = 23% LL = 48 PL = 30 Fines = 90%
190 / 30			44	SPT-8 12 32 50	50/6"	
		Lean CLAY, hard, bluish gray, dry, [Qgl] (CL)				
185 / 35			67	SPT-9 10 20 35	55	MC = 24% LL = 42 PL = 26 Fines = 92%
180 / 40		Fat CLAY with sand, very hard, bluish gray, dry, homogeneous, [Qgl] (CH)	58	SPT-10 5 50	50/6"	MC = 15% LL = 56 PL = 28 Fines = 73%
		Lean CLAY, very hard, bluish gray, dry, [Qgl] (CL)				

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PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-217-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80	TESTS AND REMARKS
		Lean CLAY, very hard, bluish gray, dry, [Qgl] (CL) *(continued)*				
175 / 45			75	SPT-11 20 35 50/4"	50/4"	
		Well graded SAND with silt and gravel, very dense, grayish brown, moist, [Qvt] (SW)				
170 / 50			100	SPT-12 50/2"	● □ 50/2"	MC = 5% Fines = 11%
		Silty SAND with gravel, very dense, light olive brown, moist, [Qvt] (SM)				
165 / 55			73	SPT-13 15 50/5"	50/5"	
160 / 60		Silty GRAVEL with sand, very dense, brownish yellow to olive yellow, moist, oxidation, [Qvt] (GM)	100	SPT-14 50/5"	50/5"	

Bottom of borehole at 60.4 feet.

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4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-218-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

DATE STARTED 8/31/20 **COMPLETED** 9/1/20 **GROUND ELEVATION** 238.6 ft NAVD88 **HOLE SIZE** 6 inches

DRILLING CONTRACTOR Boretec **DRILL RIG** EC95 **SPT HAMMER EFFICIENCY** 60%

DRILLING METHOD HSA **STATION (FT)** 5619+05.41 **OFFSET (FT)** 11.7 L

LOGGED BY JP Bourquin **CHECKED BY** Pat Reed **NORTHING** 189315.321 **EASTING** 1303096.815

NOTES **GW LEVEL (ATD)** Dry

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	SPT N VALUE / PL MC LL / FINES CONTENT (%)	TESTS AND REMARKS
0		ASPHALT (14 inches) over				
		Well graded SAND with silt and gravel, very dense, light yellowish brown, moist, fine to coarse sand and gravel, homogenous, [Qva] (SP)				
235			61	SPT-1 29 36 32	● □ ▲ 68	MC = 3% Fines = 9%
5		Silty SAND, medium dense, light olive brown, moist, homogenous, [Qva] (SM)				
			89	SPT-2 11 12 11	▲ 23	
230		Becomes dense, brownish gray, moisture increases	56	SPT-3 5 10 15	● ▲ □ 25	MC = 15% Fines = 33%
10		Becomes medium dense, light olive brown, fine to medium sand and gravel	56	SPT-4 5 10 12	▲ 22	
225						
15		Becomes very dense with gravel	89	SPT-5 14 26 39	● □ ▲ 65	MC = 11% Fines = 41%
220						
20						

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WSDOT GEOTECH DRILLING - I405 WSDOT.GDT - 11/4/20 12:31 - C:\USERS\CHELSEA.FOSTER\DOCUMENTS\PROJECTWISE\WORKINGDIR\WSDOT\DMS08721\I405 WSDOT - SEG. 1.GPJ

wood. 4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-218-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	▲ SPT N VALUE ▲ / PL MC LL / ☐ FINES CONTENT (%) ☐	TESTS AND REMARKS
20		Silty SAND with gravel, very dense, grayish brown, moist, homogenous, [Qva] (SM)	100	SPT-6 35 50/5"	50/5"	MC = 10% LL = 17 PL = 14 Fines = 45%
215 / 25		Lenses of sand (~2 to 3 inches thick)	100	SPT-7 39 50/5"	50/5"	
210 / 30		Becomes olive brown	100	SPT-8 50/5"	50/5"	MC = 5% Fines = 36%
205 / 35		Poorly graded SAND, very dense, olive brown, moist, fine to medium sand, [Qva] (SP)	120	SPT-9 50/5"	50/6"	
200 / 40			100	SPT-10 50/2"	50/2"	
		SILT, very dense, olive brown, moist, non plastic, homogenous, [Qgl] (ML)				

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wood. 4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-218-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80	TESTS AND REMARKS
195 / 45		SILT, very dense, olive brown, moist, non plastic, homogenous, [Qgl] (ML) *(continued)*				
			100	SPT-11 26 50	50/6"	MC = 22% LL = 33 PL = 25 Fines = 98%
190 / 50		Becomes bluish gray	100	SPT-12 16 29 50	50/6"	
185 / 55		Lean CLAY, hard, dark gray, moist, [Qgl] (CL)	100	SPT-13 44 50	50/6"	MC = 25% LL = 36 PL = 23 Fines = 95%
180 / 60		Dropstones	100	SPT-14 44 50	50/6"	
175 / 65		Silty SAND with gravel, very dense, reddish brown, moist, [Qpf] (SP)	100	SPT-15 50	50/6"	MC = 8% Fines = 15%

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wood.
4020 Lake Washington Blvd Suite 200
Kirkland, WA 98033

PROJECT NAME I-405 Renton to Bellevue Widening **PROJECT NUMBER** 20316 **BORING NUMBER** W-218-20

CLIENT WSDOT **PROJECT LOCATION** Renton, WA

ELEVATION (ft) / DEPTH	GRAPHIC LOG	SOIL & ROCK DESCRIPTION	RECOVERY % (RQD)	SAMPLE TYPE NUMBER	▲ SPT N VALUE ▲ 20 40 60 80 / PL MC LL 20 40 60 80 / ☐ FINES CONTENT (%) ☐ 20 40 60 80	TESTS AND REMARKS
		Silty SAND with gravel, very dense, reddish brown, moist, [Qpf] (SP) *(continued)*				Hard drilling at 65 feet with soil change
						Hard drilling at 67.5 feet
170 / 70		Silt content increases	100	SPT-16 40 50	50/6"	
165 / 75		Silty GRAVEL with sand, very dense, moist, [Qpf] (GM)	100	SPT-17 50/2"	50/2"	MC = 6% Fines = 25%
160 / 80			0	SPT-18 100/1"	100/1"	Very hard drilling at 80 feet when drilling deeper to cover auger in the road with steel plate

Bottom of borehole at 81.5 feet.

WSDOT GEOTECH DRILLING - I405 WSDOT.GDT - 11/4/20 12:31 - C:\USERS\CHELSEA.FOSTER\DOCUMENTS\PROJECTWISE\WORKINGDIR\WSDOT\DMS08721\I405 WSDOT - SEG. 1.GPJ

WSDOT Boring and Test Pit Legend

Sampler Symbols

	Standard Penetration Test
	Non-Standard Sized Penetration Test
	Shelby Tube
	Piston Sample
	Washington Undisturbed
	Vane Shear Test
	Core
	Becker Hammer
	Bag Sample

Well Symbols

	Cement Surface Seal
	Piezometer Pipe in Granular Bentonite Seal
	Piezometer Pipe in Sand
	Well Screen in Sand
	Granular Bentonite Seal
	Inclinometer Casing or PVC Pipe in Cement Bentonite Grout
	Sand
	Vibe Wire in Grout
	Miscellaneous, noted on boring log

Laboratory Testing Codes

AL	Atterberg Limits
CD	Consolidated Drained Triaxial
CN	Consolidation Test
CSS	Cyclic Simple Shear
CU	Consolidated Undrained Triaxial
DG	Degradation
DN	Density
DS	Direct Shear Test
DSS	Direct Simple Shear
GS	Grain Size Distribution
HT	Hydrometer Test
JS	Jar Slake
LA	LA Abrasion
LOI	Loss on Ignition
MC	Moisture Content
pH	pH of Soil
PT	Point Load Compressive Test
RES	Resistivity
RM	Resilient Modulus
RS	Torsional Ring Shear Test
SG	Specific Gravity
SL	Slake Test
UC	Unconfined Compression Test
UU	Unconsolidated Undrained Triaxial
HC	Hydraulic Conductivity

Soil Density Modifiers

Gravel, Sand & Non-plastic Silt		Elastic Silts and Clay	
SPT Blows/ft	Density	SPT Blows/ft	Consistency
0 - 4	Very Loose	0 - 1	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 24	Medium Dense	5 - 8	Medium Stiff
25 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
(REF)	Refusal	31 - 60	Hard
		> 60	Very Hard

Angularity

Angular	Coarse particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse grained particles are similar to angular but have rounded edges.
Subrounded	Coarse grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse grained particles have smoothly curved sides and no edges.

Soil Moisture Modifiers

Dry	Absence of moisture; dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water

Soil Structure

Stratified	Alternating layers of varying material or color at least 6 mm thick; note thickness and inclination.
Laminated	Alternating layers of varying material or color less than 6 mm thick; note thickness and inclination.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into smaller angular lumps which resist further breakdown.
Disrupted	Soil structure is broken and mixed. Infers that material has moved substantially - landslide debris.
Homogeneous	Same color and appearance throughout.

HCl Reaction

No HCl Reaction	No visible reaction.
Weak HCl Reaction	Some reaction with bubbles forming slowly.
Strong HCl Reaction	Violent reaction with bubbles forming immediately.

Degree of Vesicularity of Pyroclastic Rocks

Slightly Vesicular	5 to 10 percent of total
Moderately Vesicular	10 to 25 percent of total
Highly Vesicular	25 to 50 percent of total
Scoriaceous	Greater than 50 percent of total

WSDOT

Boring and Test Pit Legend

Grain Size

Fine Grained	< 0.04 in	Few crystal boundaries/grains are distinguishable in the field or with hand lens.
Medium Grained	0.04 to 0.2 in	Most crystal boundaries/grains are distinguishable with the aid of a hand lens.
Coarse Grained	> 0.2 in	Most crystal boundaries/grains are distinguishable with the naked eye.

Weathered State

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration in major discontinuity surfaces.	I
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than its fresh condition.	II
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	III
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as core stone.	IV
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual Soil	All rock material is converted to soil. The mass structure and material fabric is destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Relative Rock Strength

Grade	Description	Field Identification	Uniaxial Compressive Strength approx
R1	Very Weak	Specimen crumbles under sharp blow from point of geological hammer, and can be cut with a pocket knife.	0.15 to 3.6 ksi
R2	Moderately Weak	Shallow cuts or scrapes can be made in a specimen with a pocket knife. Geological hammer point indents deeply with firm blow.	3.6 to 7.3 ksi
R3	Moderately Strong	Specimen cannot be scraped or cut with a pocket knife, shallow indentation can be made under firm blows from a hammer.	7.3 to 15 ksi
R4	Strong	Specimen breaks with one firm blow from the hammer end of a geological hammer.	15 to 29 ksi
R5	Very Strong	Specimen requires many blows of a geological hammer to break intact sample.	Greater than 29 ksi

Discontinuities

Spacing	
Very Widely	Greater than 10 ft
Widely	3 ft to 10 ft
Moderately	1 ft to 3 ft
Closely	2 inches to 12 inches
Very Closely	Less than 2 inches

RQD (%)

$$\frac{100(\text{length of core in pieces} > 100\text{mm})}{\text{Length of core run}}$$

Condition	
Excellent	Very rough surfaces, no separation, hard discontinuity wall
Good	Slightly rough surfaces, separation less than 0.05 in, hard discontinuity wall.
Fair	Slightly rough surfaces, separation greater than 0.05 in, soft discontinuity wall.
Poor	Slickensided surfaces, or soft gouge less than 0.2 in thick, or open discontinuities 0.05 to 0.2 in.
Very Poor	Soft gouge greater than 0.2 in thick, or open discontinuities greater than 0.2 in.

Fracture Frequency (FF) is the average number of fractures per 1 ft of core. This does not include mechanical breaks caused by drilling or handling.

Datum:
NAD 83/91 HARN = North American Datum of 1983/1991 High Accuracy Reference Network
NAVD88 = North American Vertical Datum of 1988
SPN (ft) = State Plane North (ft)
SPS (ft) = State Plane South (ft)

WSDOT

LOG OF TEST BORING

Start Card SE-61806 / AE-42502

HOLE No. R2B-10-17

Job No. XL-4653 SR 405 Elevation 210.2 ft

Sheet 1 of 2

Project I-405 Renton to Bellevue - ETL - Envir & Traff

Driller Henderson, Danny Lic# 2742

Component Fill Wall 05.85L

Inspector Harvey, Thomas #2599

Start April 12, 2017 Completion April 12, 2017 Well ID# N/A

Equipment CME 45C (9A4-7)

Station SB405 5617+28.003 Offset 54.4 feet left Hole Dia (inches) 4

Historical SPT Efficiency 88.4%

Northing 189137.226 Easting 1303059.157 Collected by Region Survey Crew

Method Casing Advancer

Lat 47.5103052 Long -122.1984486 Datum NAD 83/91 HARN, NAVD88, SPN (ft)

Drill Fluid Bentonite

SPT Efficiency
Field SPT (N)
Moisture Content
RQD
20 40 60 80

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	210.0							
		26 27 24 (51)		D-1		Silty SAND, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
5	205.0							
		4 8 8 (16)		D-2	MC GS AL	SM, MC=19%, LL=19 Silty SAND with organics, medium dense, grayish brown, moist, stratified. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
		4 5 7 (12)		D-3		Silty SAND, medium dense, gray, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
10	200.0							
		2 3 5 (8)		D-4	MC LOI	MC=33%, LOI=7.2% Sandy SILT with organics, loose, gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
		4 6 15 (21)		D-5		Silty SAND with gravel, sub-rounded, medium dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
15	195.0							
		20 24		D-6		Silty SAND with gravel, sub-rounded, dense, brown, moist, homogeneous. HCl not tested.		
20								

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

WSDOT

LOG OF TEST BORING

Job No. XL-4653 SR 405 Elevation 210.2 ft HOLE No. R2B-10-17

Sheet 2 of 2

Project I-405 Renton to Bellevue - ETL - Envir & Traff Driller Henderson, Danny

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency / Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	190			24 (48)				Recovered: 1.0 ft Retained: 1.0 ft		
				16 18 17 (35)		D-7	MC GS	MC=18% Silty SAND, dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
25	185									
				15 24 26 (50)		D-8		Silty SAND, dense, brown, moist, stratified. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
30	180									
35	175							The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
								End of test hole boring at 30.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
40	170							Bail/Recharge test: Hole Diameter: 4 inches Depth of boring during bail test: 30.5 ft. Depth of casing during bail test: 24 ft. Water depth before bailing: 12.7 ft. Bailed bore hole water level to 20.1 ft. Recharge after 5 minutes: 20.1 ft. Recharge after 10 minutes: 20.3 ft. Recharge after 15 minutes: 20.3 ft. Recharge after 30 minutes: 20.4 ft.		
45										

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

WSDOT

LOG OF TEST BORING

Start Card SE-61806 / AE-42502

Job No. XL-4653 SR 405 Elevation 219.2 ft

HOLE No. R2B-11-17

Sheet 1 of 3

Project I-405 Renton to Bellevue - ETL - Envir & Traff

Driller Peterson, Trevor Lic# 3008

Component Fill Wall 05.85L

Inspector Harvey, Thomas #2599

Start April 13, 2017 Completion April 13, 2017 Well ID# N/A

Equipment CME 45C (9A4-7)

Station SB405 5617+34.677 Offset 35.6 feet left Hole Dia (inches) 4

Historical SPT Efficiency 88.4%

Northing 189144.191 Easting 1303075.854 Collected by Region Survey Crew

Method Casing Advancer

Lat 47.5103251 Long -122.1983816 Datum NAD 83/91 HARN, NAVD88, SPN (ft)

Drill Fluid Bentonite

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency / Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	215.0			15 22 14 (36)		D-1		Silty SAND with gravel, sub-rounded, dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
5										
				5 5 6 (11)		D-2	MC GS AL	SM, MC=15%, LL=18 Silty SAND with gravel and organics, sub-rounded, medium dense, gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
	210.0			4 5 8 (13)		D-3		Silty SAND with gravel, sub-rounded, medium dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
10										
				7 7 10 (17)		D-4		Silty SAND with gravel and organics, sub-rounded, medium dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.1 ft Retained: 0.1 ft		
	205.0			14 10 5 (15)		D-5	MC LOI	MC=32%, LOI=7.3% Silty SAND with gravel and organics, sub-rounded, medium dense, dark gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
15										
	200.0			12 10		D-6		SILT, medium dense, light brown, moist, homogeneous. HCl not tested.		
20										

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

WSDOT

LOG OF TEST BORING

Job No. XL-4653 SR 405 Elevation 219.2 ft HOLE No. R2B-11-17

Sheet 2 of 3

Project I-405 Renton to Bellevue - ETL - Envir & Traff Driller Peterson, Trevor

SPT Efficiency
Field SPT (N)
Moisture Content
RQD

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
		8 (18)				Recovered: 1.0 ft Retained: 1.0 ft		
	195	6 8 10 (18)	D-7		MC GS AL	ML, MC=31%, PI=3 SILT, medium dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
25								
	190	>> 50/4" (REF)	D-8			Clayey SAND with gravel, sub-angular, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
30								
	185	>> 27 50/6" (REF)	D-9		MC GS AL	SC, MC=11%, PI=9 Clayey SAND with gravel, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
35								
	180	>> 50/6" (REF)	D-10			Clayey SAND with gravel, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
40								
	175	27 30	D-11			Clayey SAND with gravel, sub-angular, very dense, brown, moist, homogeneous. HCl not tested.		
45								

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

WSDOT

LOG OF TEST BORING

Job No. XL-4653 SR 405 Elevation 219.2 ft HOLE No. R2B-11-17

Sheet 3 of 3

Project I-405 Renton to Bellevue - ETL - Envir & Traff Driller Peterson, Trevor

SPT Efficiency
Field SPT (N)
Moisture Content
RQD
20 40 60 80

Depth (ft)	Elevation (ft)	Profile	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			30 (60)				Recovered: 0.8 ft Retained: 0.8 ft		
	170		>> 50/2" (REF)		D-12		No Recovery.		
50									
	165		24 34 38 (72)		D-13	MC GS	MC=17% Silty SAND with organics, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
55									
	160		23 23 26 (49)		D-14		Silty SAND, sub-angular, dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
60									
							The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew. End of test hole boring at 60.5 ft below ground elevation. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal Bail/Recharge test: Hole Diameter: 4 inches Depth of boring during bail test: 60.5 ft. Depth of casing during bail test: 54 ft. Water depth before bailing: 6 ft. Bailed bore hole water level to 37.3 ft. Recharge after 5 minutes: 29.5 ft. Recharge after 10 minutes: 27.1 ft. Recharge after 15 minutes: 25.7 ft. Recharge after 20 minutes: 23.5 ft. Recharge after 25 minutes: 21.8 ft. Recharge after 30 minutes: 21.8 ft.		
	155								
65									
	150								
70									

ENTERPRISE BORING LOG XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ ENTERPRISE DATA TEMPLATE.GDT 5/11/18

LOG OF TEST BORING — WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

___ S.H. ___ S.R. 405 SECTION Sunset Blvd. to Factoria I/C — Job No. C-2637

Hole No. 1 — Sub Section ___ — Cont. Sec. 1744

Station 377+44 — Offset 109.0' Lt. ℄ — Ground El. 197.0'

Type of Boring Wash Boring — Casing 3" x 14.0' — W.T. El. See bottom of log.

Inspector ___ — Date January 18, 1985 — Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				Brown, fine to coarse, sandy GRAVEL.
			1 STD	Very loose, brown, moist, gravelly, silty, fine to coarse SAND. (Fill)
	4		2 PEN	Retained 0.7'.
			2 1	
			2	
			3 STD	Loose, brown, moist, gravelly, silty, fine to coarse SAND. (Fill)
	8		4 PEN	Retained 0.6'.
5			4 2	
			4	
			1 STD	Very loose, brown, moist, gravelly, very silty, fine to coarse SAND
	3		2 PEN	with pieces of embers. Retained 0.5'.
			1 3	
			1	
			2 STD	Very loose, brown, moist, gravelly, very silty, fine to coarse SAND.
			3 PEN	Retained 1.2'.
	4		1 4	
			3	
10				
			6 STD	Loose, brown, moist, silty, gravelly, fine to coarse SAND. Retained 1.
	10		5 PEN	
			5 5	
			4	
			2 STD	
			4 PEN	Loose, brown, wet, very silty, fine SAND. Retained 0.7'.
	9		5 6	
			6	
15				
			3 STD	
	118/11"		18 PEN	
			100/ 7	Very dense, brown, moist, silty, gravelly, fine to coarse SAND.
			5"	Retained 1.1'.
			45 STD	
			97 PEN	Very dense, brown, moist, silty, gravelly, fine to coarse SAND.
	197/9"		100/ 8	Retained 0.8'.
			3"	
20				

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ___

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. 1 Sub Section Sunset Blvd. to Factoria I/C Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	100/3"		100/ STD 3" PEN 9	Very dense, brown, moist, silty, gravelly, fine to coarse SAND. Retained 3".
25	100/4"		100/ STD 4" PEN 10	Very dense, brown, moist, silty, gravelly, fine to coarse SAND. Retained 4".
				End of boring 25.0' below ground elevation. Water elevation undetermined.
				Note: Did not encounter any loss of drilling fluid until the depth of -24.0', then only slight loss.
				Note: Installed piezometer to a depth of -25.0'. Overall length of piezometer 27.5'. Piezometer slotted at -10.0' to -12.0' and -22.0' to -24.0'.
				Note: Samples appeared disturbed to -13.0'.
				January 18, 1985 with 14.0' of casing; filled casing with water, no drop by January 21, 1985
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

Piezometer Readings

CONTRACT No. C 2637		Total Length of Pipe	27.5'
		Elevation Top of Pipe	199.5
Hole No. 1		Ground Elevation	197.0'
Station 377+44 Offset 109.0' LT		Length of Pipe above Ground	2.5'

DATE	Water Reading	Water Elevation	Remarks
1-29-85	-15.5'	184.0'	INITIAL READING
1-30-85	-12.0'	187.5'	PIPE SLOTTED 10.0' TO
2-1-85	-12.0	187.5'	12.0' AND 22.0' TO
2-19-85	9.8'	189.7'	24.0'
2-21-85	10.0'	189.5'	

LOG OF TEST BORING — WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

___ S.H. ___ S.R. 405 SECTION Sunset Blvd. to Factoria I/C — Job No. C-2637

Hole No. 2 — Sub Section ___ — Cont. Sec. 1744

Station 376+35 — Offset 115.0' Lt. — Ground El. 182.5'

Type of Boring Wash Boring — Casing 3" x 20.0' — W.T. El. See bottom of log.

Inspector ___ — Date January 23, 1985 — Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
				MUCK
	7		4 STD 4 PEN 3 1 5	Loose, brown, moist, silty, gravelly, fine to coarse SAND with wood fragments and cobbles. Retained 0.6'.
	17		5 STD 8 PEN 9 2 7	Medium dense, brown, moist, gravelly, very silty, fine to coarse SAND. Retained 1.0'.
5				
	13		5 STD 5 PEN 8 3 8	Medium dense, brown, moist, gravelly, silty, fine to coarse SAND with wood fragments. Retained 1.0'.
	20		7 STD 9 PEN 11 4 10	Medium dense, brown, moist, gravelly, silty, fine to coarse SAND. Retained 1.1'.
10				
	8		6 STD 4 PEN 4 5 5	Loose, brown, moist, gravelly, silty, fine to coarse SAND. Retained 0.2'.
	7		5 STD 4 PEN 3 6 3	No recovery.
15				
	7		6 STD 3 PEN 4 7 4	Loose, brown, moist, gravelly, very silty, fine to coarse SAND. Retained 1.0'.
	20		6 STD 9 PEN 11 8 9	Medium dense, brown, wet, gravelly, very silty, fine to coarse SAND with pieces of wood and roots.
20				

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ___

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. 2 Sub Section Sunset Blvd. to Factoria I/C Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
			5 STD	Loose, brown, moist, gravelly, very silty, fine to coarse SAND.
	10		5 PEN	Retained 1.0'.
			5 9	
			5	
			4 STD	
			2 PEN	Loose, brown, moist, gravelly, very silty, fine to coarse SAND.
	7		5 10	Retained 2.0'.
			5	
25				
			17 STD	Medium dense, brown, moist, gravelly, very silty, fine to coarse SAND.
			8 PEN	Retained 2.0'.
	18		10 11	
			9	
			8 STD	
			8 PEN	Medium dense, brown, wet, fine to medium sandy SILT. Retained 1.1'.
	17		9 12	
			7	
30				
			4 STD	Medium dense, brown, wet, fine sandy SILT. Retained 1.2'.
			4 PEN	
	11		7 13	
			7	
			8 STD	
			10 PEN	Medium dense, brown, wet, very silty, fine SAND. Retained 1.4'.
	21		11 14	
			11	
35				
			9 STD	Medium dense, brown, moist, gravelly, very silty, fine to coarse SAND.
			8 PEN	Retained 1.5'.
	16		8 15	
			9	
			9 STD	
			22 PEN	Very dense, brown, moist, silty, gravelly, fine to coarse SAND.
	71		49 16	Retained 1.0'.
			54	
40				
				End of boring 39.5' below ground elevation.
				Note: January 29, 1985: With 20.0' of casing ground - water level was 23.0' below ground elevation.
				This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data.

LOG OF TEST BORING — WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

S.H. ____ S.R. 405 SECTION Sunset Blvd. to Factoria I/C Job No. C-2637

Hole No. 3 Sub Section ____ Cont. Sec. 1744

Station 377+50 Offset 70.0' Lt. ℄ Ground El. 212.4'

Type of Boring Wash Boring Casing 22.5' x 3" W.T. El. See bottom of log.

Inspector ____ Date January 30, 1985 Sheet 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
	5		1 STD 1 PEN 4 1 1	Loose, brown, dry, slightly silty, gravelly, fine to coarse SAND with cobbles to 10". (Fill) Retained 0.6'.
	3		1 STD 1 PEN 2 2 1	Very loose, brown, dry, slightly silty, gravelly, fine to coarse SAND with cobbles to 10". (Fill) Retained 0.4'.
5	5		4 STD 2 PEN 3 3 3	Loose, brown, moist, slightly silty, gravelly, fine to coarse SAND with cobbles. (Fill) Retained 0.8'.
	11		5 STD 4 PEN 7 4 4	Medium dense, brown, moist, slightly silty, gravelly, fine to coarse SAND with cobbles. (Fill) Retained 0.6'.
10	5		3 STD 2 PEN 3 5 3	Loose, brown, moist, slightly silty, gravelly, fine to coarse SAND. Retained 0.4'.
	8		5 STD 5 PEN 3 6 4	Note: Filled casing with water evening of January 30, 1985; no loss of water noted morning of January 31, 1985. Loose, brown, moist, silty, gravelly, fine to coarse SAND with trace of organic. Retained 0.5'.
15	6		5 STD 3 PEN 3 7 5	Loose, brown, moist, silty, gravelly, fine to coarse SAND. Retained 0.3'.
	11		7 STD 5 PEN 6 8 9	Medium dense, brown, moist, silty, fine to coarse SAND. Retained 0.4'
20				

DOT FORM 351-003 REVISED 12/79

Original to Materials Engineer
Copy to Bridge Engineer
Copy to District Administrator

Copy to ____

HWY Form 351-003-a (H. F. 26.66-A).
Revised 5-67.

Hole No. 3 Sub Section Sunset Blvd. to Factoria I/C Sheet 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.		DESCRIPTION OF MATERIAL
			7	STD	Medium dense, brown, moist, silty, fine to coarse SAND. Retained 0.2'
	19		9	PEN	
			10	9	
			14		Gray, wet, slightly sandy, slightly gravelly SILT.
			25	STD	
			48	PEN	Very dense, brown, moist, silty, gravelly, fine to coarse SAND.
	118		70	10	Retained 1.7'.
			100/3"		Note: Filled casing with water evening of January 31, 1985; water
25					elevation -9.7' morning of February 1, 1985.
			45	STD	Very dense, brown, moist, silty, gravelly, fine to coarse SAND.
	153		59	PEN	Retained 1.1'.
			94	11	
			100		
					End boring 27.0' below ground elevation.
30					
					Note: Water-bearing gravel from -7.5' to -11.5'. Experienced slight
					loss of drilling fluid upper 11.0'.
					Note: Drilled dry from -0.0' to -7.5'.
					Washed bored hole from -7.5' to -27.0'
					Note: Piezometer installed February 4, 1985.
					Overall length of piezometer 18.0'. Piezometer in ground 15.0'.
					Slotted from -14.0' to -12.0'.
					Water elevation undetermined at this time.
					Top 3.0' of piezometer sealed with bentonite.
					This is a summary Log of Test Boring. Soil/Rock descriptions are
					derived from visual field identifications and laboratory test data.

Piezometer Readings

CONTRACT No. C-2637		Total Length of Pipe	18.0'
		Elevation Top of Pipe	215.4'
Hole No. 3		Ground Elevation	212.4'
Station 377+50 Offset 70.0' Lt. ℄		Length of Pipe above Ground	3.0'

DATE	Water Reading	Water Elevation	Remarks
2-8-1985	10.0	205.4	Initial reading
2-19-1985	9.0'	206.4	Pipe slotted -10.0' to
2-21-1985	9.0'	206.4	-12.0'

FLATIRON | LANE | wood.

In Association with

Appendix B
Laboratory Test Results

EXPLORATION DESIGNATION	TOP DEPTH (feet)	BOTTOM DEPTH (feet)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS (%)			% GRAVEL	% SAND	% FINES	ASTM SOIL CLASSIFICATION	SAMPLE DESCRIPTION
						LL	PL	PI					
W-201-20,S-3	7.5	9.0	15.2			30	21	9	1.7	34.3	64.0	CL	Light olive-brown, sandy lean CLAY
W-201-20,S-5	15.0	16.5	20.7							22.0	78.0	ML	Light olive-brown, SILT with sand
W-201-20,S-6	20.0	21.5	25.7			37	24	13		1.2	98.8	CL	Gray, lean CLAY
W-201-20,S-8	30.0	31.5	23.4			38	26	12	0.5	9.6	90.0	ML	Grayish-brown, SILT
W-201-20,S-9	35.0	36.5	11.2							44.7	55.3	ML	Light olive-brown, sandy SILT
W-201-20,S-11	45.0	46.5	12.6							38.1	61.9	ML	Light olive-brown, sandy SILT
W-201-20,S-14	60.0	61.5	22.7						0.4	84.8	14.8	SM	Dark olive-gray, silty SAND
W-203-20,S-1	2.5	4.0	2.8						56.5	38.5	5.0	GP-GM	Olive-gray, poorly graded GRAVEL with silt and sand
W-203-20,S-2	5.0	6.5	5.7						36.7	44.6	18.8	SM	Olive-brown, silty SAND with gravel
W-203-20,S-3	7.5	9.0	10.5								29.5	SM	Olive-gray, silty SAND
W-203-20,S-4	10.0	11.5	12.2								24.1	SM	Dark gray, silty SAND
W-203-20,S-5	15.0	16.5	11.9								22.9	SM	Dark olive-gray, silty SAND
W-203-20,S-6	20.0	21.5	9.9						13.0	76.0	11.0	SW-SM	Dark gray, well-graded SAND with silt
W-203-20,S-7	25.0	26.5	11.5			19	17	2	27.2	42.7	30.1	SM	Olive-brown, silty SAND with gravel
W-207-20,S-2	5.0	6.5	10.8						13.9	49.0	37.2	SM	Olive-brown, silty SAND
W-207-20,S-4	10.0	11.5	10.0						15.0	53.6	31.4	SM	Olive-brown, silty SAND with gravel
W-207-20,S-5	15.0	16.5	17.0			28	20	8	16.1	33.8	50.1	CL	Olive-brown, sandy lean CLAY with gravel
W-207-20,S-8	30.0	31.5	14.5						8.1	64.2	27.6	SM	Olive-brown, silty SAND
W-208-20,S-1	2.5	4.0	9.8						8.6	74.4	17.0	SM	Olive-brown, silty SAND
W-208-20,S-3	7.5	9.0	8.7						7.4	58.9	33.7	SM	Grayish-brown, silty SAND

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report test, other graphs and tables, and the exploration logs.
2. The soil classifications in this table are based on ASTM D2487 and D2488 as applicable.

EXPLORATION DESIGNATION	TOP DEPTH (feet)	BOTTOM DEPTH (feet)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS (%)			% GRAVEL	% SAND	% FINES	ASTM SOIL CLASSIFICATION	SAMPLE DESCRIPTION
						LL	PL	PI					
W-208-20,S-5	15.0	16.5	8.9						0.9	58.6	40.6	SM	Olive-brown, silty SAND
W-208-20,S-7	25.0	26.5	12.8						3.3	47.5	49.3	SM	Olive-brown, silty SAND
W-208-20,S-8B	30.0	31.5	29.8			45	21	24	1.3	20.5	78.2	CL	Gray, lean CLAY with sand
W-208-20,S-9	35.0	36.5	9.5			17	13	4	10.2	46.9	42.9	SC-SM	Olive-brown, silty, clayey SAND
W-208-20,S-10	40.0	41.5	12.0						8.2	62.1	29.8	SM	Olive-brown, silty SAND
W-214-20,S-1	2.5	4.0	10.1	1.6		39	17	22	7.2	45.5	47.3	SC	Olive-brown, clayey SAND
W-214-20,S-2	5.0	6.5	31.2						0.6	9.7	89.7	ML	Grayish-brown, SILT
W-214-20,S-4	10.0	11.5	11.4			34	24	10	47.5	38.0	14.5	GM	Olive-brown, silty GRAVEL with sand
W-214-20,S-7	25.0	26.5	11.2						4.9	59.2	36.0	SM	Light olive-brown, silty SAND
W-214-20,S-9	35.0	36.5	21.3			23	20	3	0.7	38.6	60.7	ML	Light olive-brown, sandy SILT
W-215-20,S-1	2.5	4.0	9.6						3.5	66.7	29.8	SM	Grayish-brown, silty SAND
W-215-20,S-3	7.5	9.0	14.9						0.4	76.4	23.2	SM	Olive-brown, silty SAND
W-215-20,S-5B	16.0	16.5	18.8			NP	NP	NP		28.1	71.9	ML	Light olive-brown, SILT with sand
W-215-20,S-7	25.0	26.5	17.9							77.5	22.5	SM	Light olive-brown, silty SAND
W-217-20,S-1	2.5	4.0	8.4						4.7	50.3	45.0	SM	Grayish-brown, silty SAND
W-217-20,S-3	7.5	8.8	8.8								36.8	SM	Grayish-brown, silty SAND
W-217-20,S-5	15.0	16.0	11.8								40.3	SM	Light brownish-gray, silty SAND
W-217-20,S-7	25.0	26.5	23.4			48	30	18	0.1	10.0	89.9	ML	Gray, SILT
W-217-20,S-9	35.0	36.5	24.2			42	26	16		8.0	92.0	CL	Gray, lean CLAY
W-217-20,S-10	40.0	41.0	15.4			56	28	28	8.5	18.9	72.5	CH	Gray, fat CLAY with sand

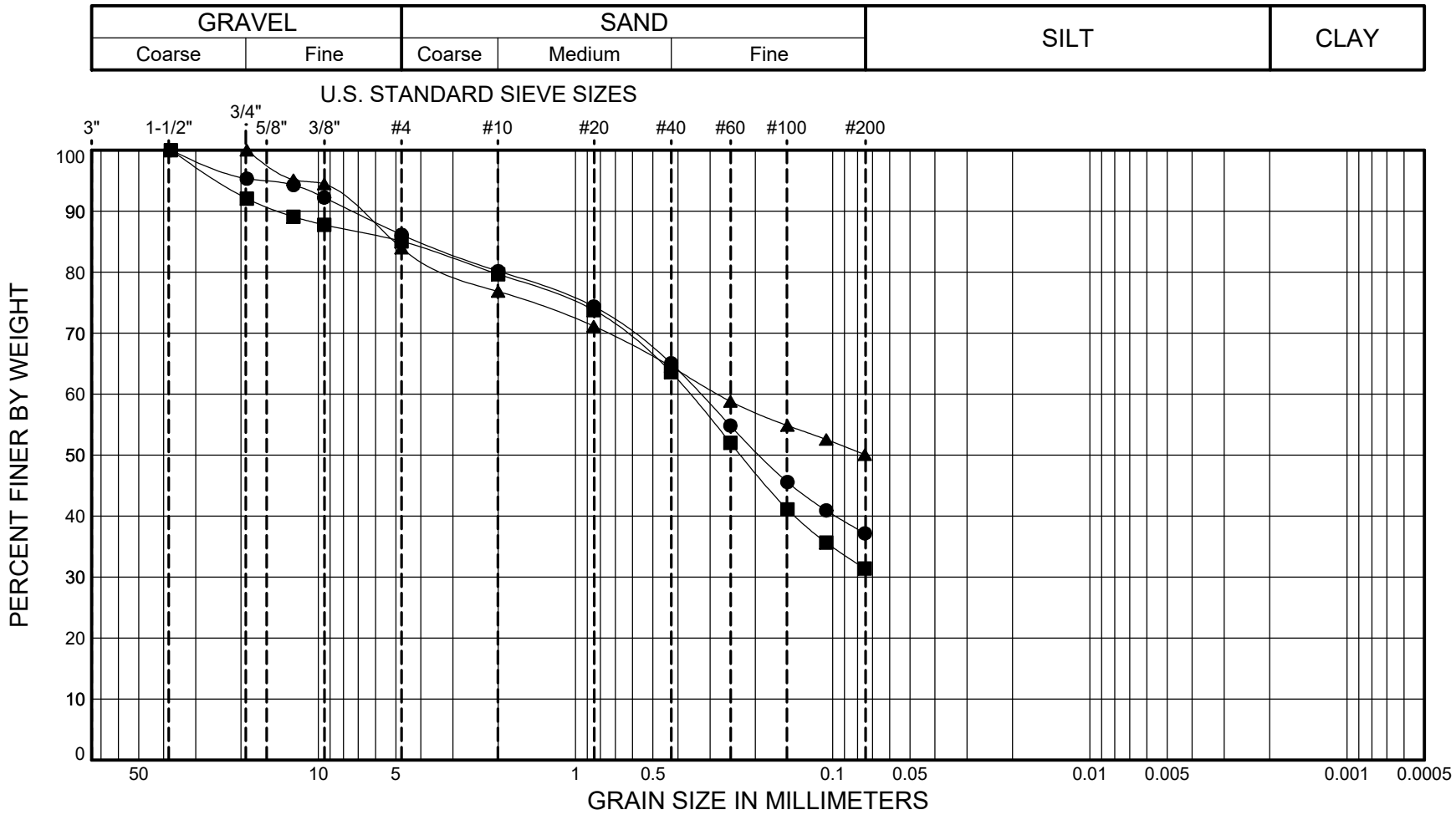
Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report test, other graphs and tables, and the exploration logs.
2. The soil classifications in this table are based on ASTM D2487 and D2488 as applicable.

EXPLORATION DESIGNATION	TOP DEPTH (feet)	BOTTOM DEPTH (feet)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS (%)			% GRAVEL	% SAND	% FINES	ASTM SOIL CLASSIFICATION	SAMPLE DESCRIPTION
						LL	PL	PI					
W-217-20,S-12	50.0	50.8	4.5						33.2	55.6	11.2	SW-SM	Grayish-brown, well-graded SAND with silt and gravel
W-221-20,S-2	5.0	6.5	18.8						5.9	74.2	19.9	SM	Dark yellowish-brown, silty SAND
W-221-20,S-3	7.5	9.0	13.0			23	15	8	6.6	48.8	44.6	SC	Grayish-brown, clayey SAND
W-221-20,S-4	10.0	11.5	13.5						11.8	59.6	28.5	SM	Olive-brown, silty SAND
W-221-20,S-5	15.0	16.5	23.6			50	28	22	7.2	17.6	75.2	CH	Grayish-brown, fat CLAY with sand
W-221-20,S-7	25.0	26.5	31.2			41	25	16		5.5	94.5	CL	Dark gray, lean CLAY
W-221-20,S-8	30.0	31.5	37.3			34	23	11	2.9	11.8	85.4	CL	Dark gray, lean CLAY

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report test, other graphs and tables, and the exploration logs.
2. The soil classifications in this table are based on ASTM D2487 and D2488 as applicable.

EXPLORATION DESIGNATION	TOP DEPTH (feet)	BOTTOM DEPTH (feet)	MOISTURE CONTENT (%)	ORGANIC CONTENT (%)	SPECIFIC GRAVITY	ATTERBERG LIMITS (%)			% GRAVEL	% SAND	% FINES	ASTM SOIL CLASSIFICATION	SAMPLE DESCRIPTION
						LL	PL	PI					
W-206-20,S-8	30.0	31.5	24.3			NP	NP	NP		19.1	80.9	ML	Olive, SILT with sand
W-216-20,S-1	2.5	4.0	7.9						14.4	56.3	29.3	SM	Light olive-brown, silty SAND
W-216-20,S-2	5.0	6.5	12.0						1.4	47.1	51.6	ML	Olive-brown, sandy SILT
W-216-20,S-4	10.0	11.0	8.0						7.4	56.7	35.9	SM	Light olive-brown, silty SAND
W-216-20,S-6	20.0	21.5	5.0							89.9	10.1	SP-SM	Grayish-brown, poorly graded SAND with silt
W-218-20,S-1	2.5	4.0	2.8						38.9	52.0	9.1	SW-SM	Grayish-brown, well-graded SAND with silt and gravel
W-218-20,S-3	7.5	9.0	15.5						9.1	57.9	33.0	SM	Dark olive-brown, silty SAND
W-218-20,S-5	15.0	16.5	10.6						20.3	38.5	41.2	SM	Light olive-brown, silty SAND with gravel
W-218-20,S-6	20.0	21.0	10.0			17	14	3	17.6	37.1	45.3	SM	Dark grayish-brown, silty SAND with gravel
W-218-20,S-8	30.0	30.5	5.3						28.1	36.1	35.8	SM	Grayish-brown, silty SAND with gravel
W-218-20,S-11	45.0	46.0	21.8			33	25	8		1.9	98.1	ML	Olive-brown, SILT
W-218-20,S-13	55.0	56.0	24.8			36	23	13	1.1	3.9	95.0	CL	Very dark gray, lean CLAY
W-218-20,S-15	65.0	65.5	8.0						34.2	50.7	15.1	SM	Dark olive brown, silty SAND with gravel
W-218-20,S-17	75.0	75.2	6.4						38.1	37.3	24.6	GM	Dark grayish-brown, silty GRAVEL with sand
W-219-20,S-1	2.5	4.0	6.1						14.0	46.1	39.9	SM	Light olive-brown, silty SAND
W-219-20,S-3	7.5	9.0	7.8						6.2	51.7	42.1	SM	Olive-brown, silty SAND
W-219-20,S-5	15.0	16.5	7.5						1.1	52.8	46.1	SM	Olive-brown, silty SAND
W-219-20,S-7	25.0	26.5	5.0						4.8	58.0	37.2	SM	Dark gray, silty SAND
W-219-20,S-9	35.0	36.5	6.8						17.1	45.1	37.8	SM	Dark gray, silty SAND with gravel
W-220-20,S-1	2.5	4.0	3.9						2.5	84.8	12.7	SM	Light yellowish-brown, silty SAND

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report test, other graphs and tables, and the exploration logs.
2. The soil classifications in this table are based on ASTM D2487 and D2488 as applicable.



SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-207-20	S-2	5.0 - 6.5	(SM) Olive-brown, silty SAND	11				13.9	49.0			37.2
■	W-207-20	S-4	10.0 - 11.5	(SM) Olive-brown, silty SAND with gravel	10				15.0	53.6			31.4
▲	W-207-20	S-5	15.0 - 16.5	(CL) Olive-brown, sandy lean CLAY with gravel	17	28	20	8	16.1	33.8			50.1

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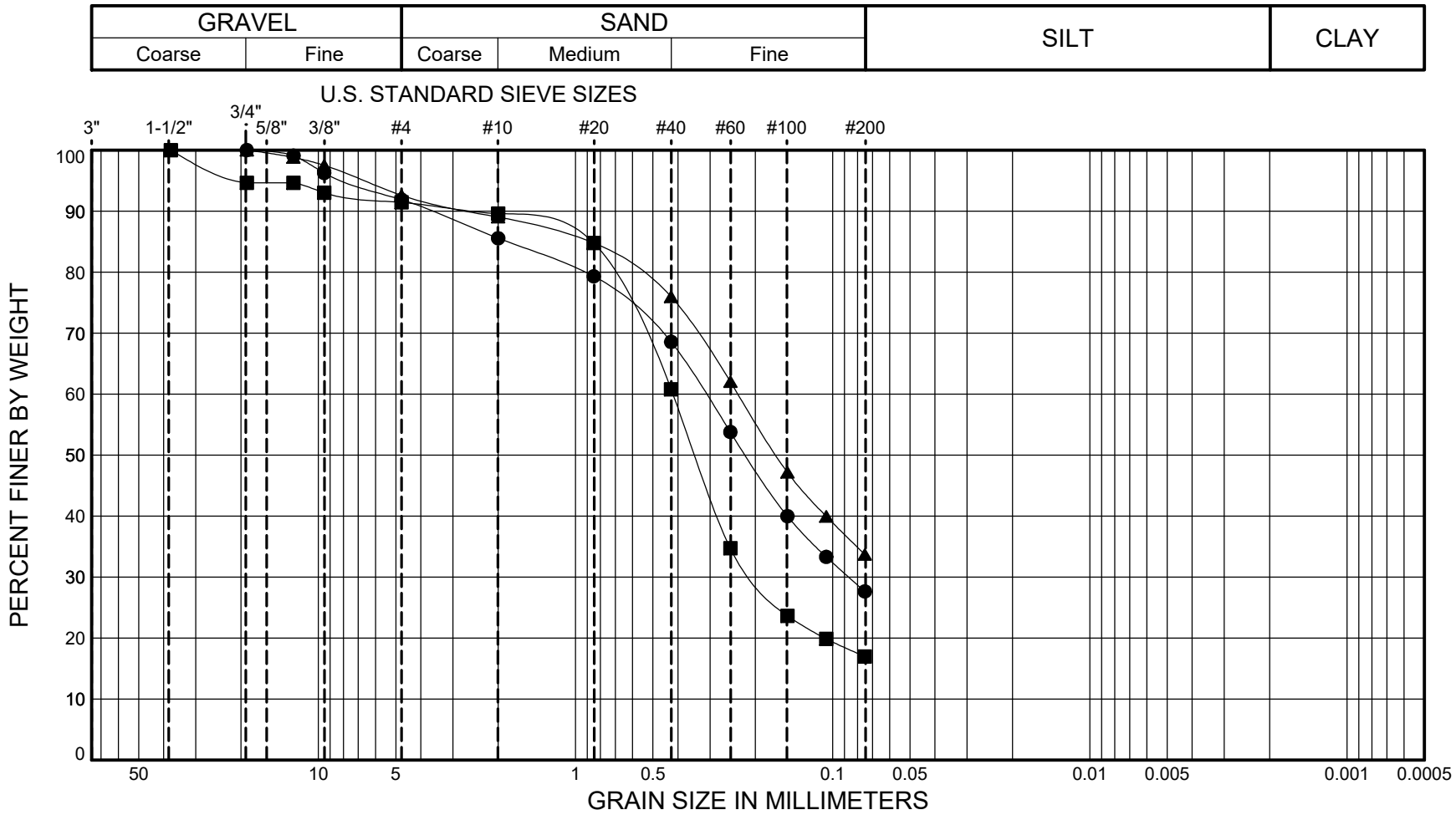
I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 16



SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-207-20	S-8	30.0 - 31.5	(SM) Olive-brown, silty SAND	14				8.1	64.2			27.6
■	W-208-20	S-1	2.5 - 4.0	(SM) Olive-brown, silty SAND	10				8.6	74.4			17.0
▲	W-208-20	S-3	7.5 - 9.0	(SM) Grayish-brown, silty SAND	9				7.4	58.9			33.7

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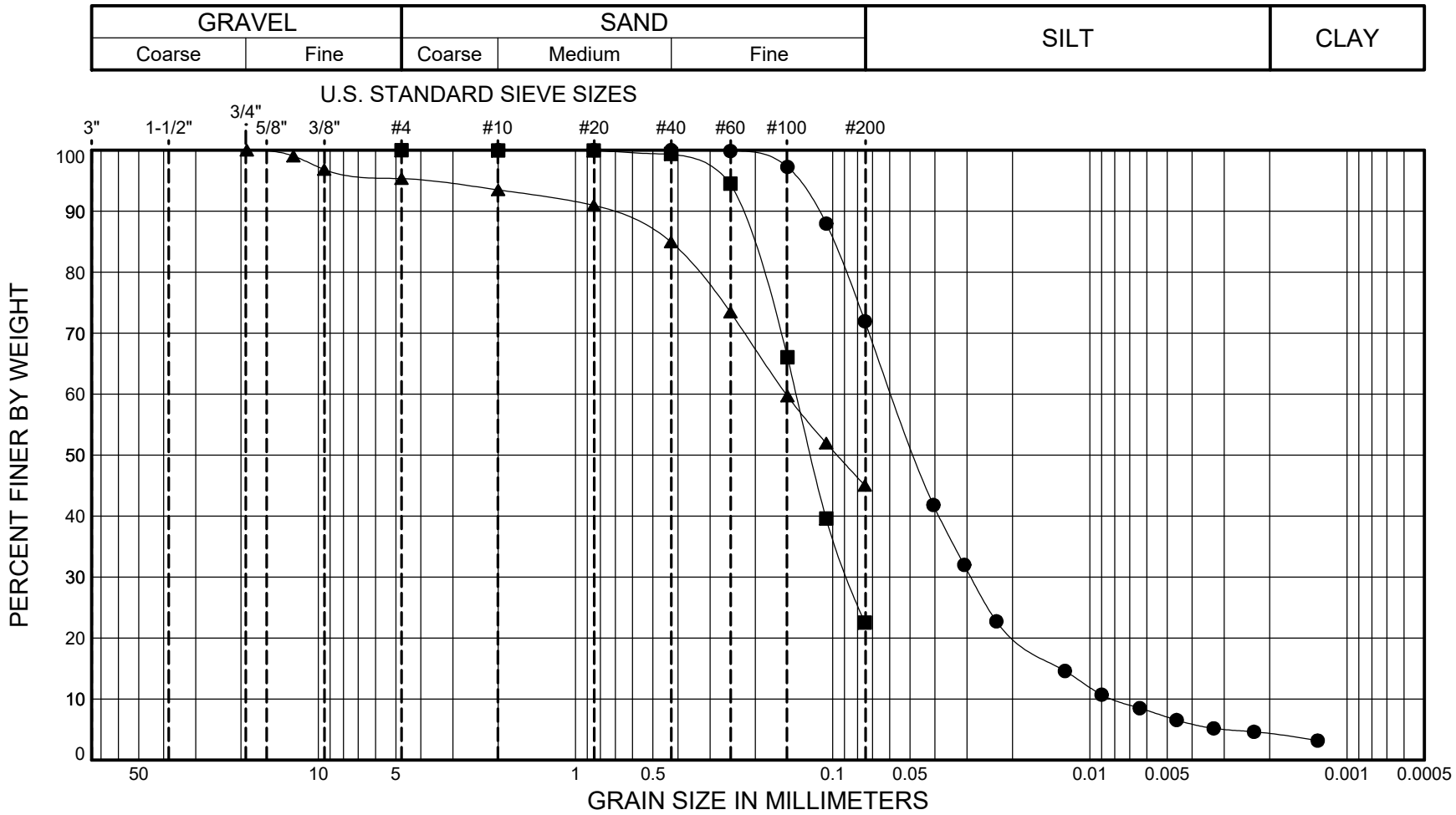
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 17



SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-215-20	S-5B	16.0 - 16.5	(ML) Light olive-brown, SILT with sand	19	NP	NP	NP		28.1	67.7	4.3	
■	W-215-20	S-7	25.0 - 26.5	(SM) Light olive-brown, silty SAND	18					77.5			22.5
▲	W-217-20	S-1	2.5 - 4.0	(SM) Grayish-brown, silty SAND	8				4.7	50.3			45.0

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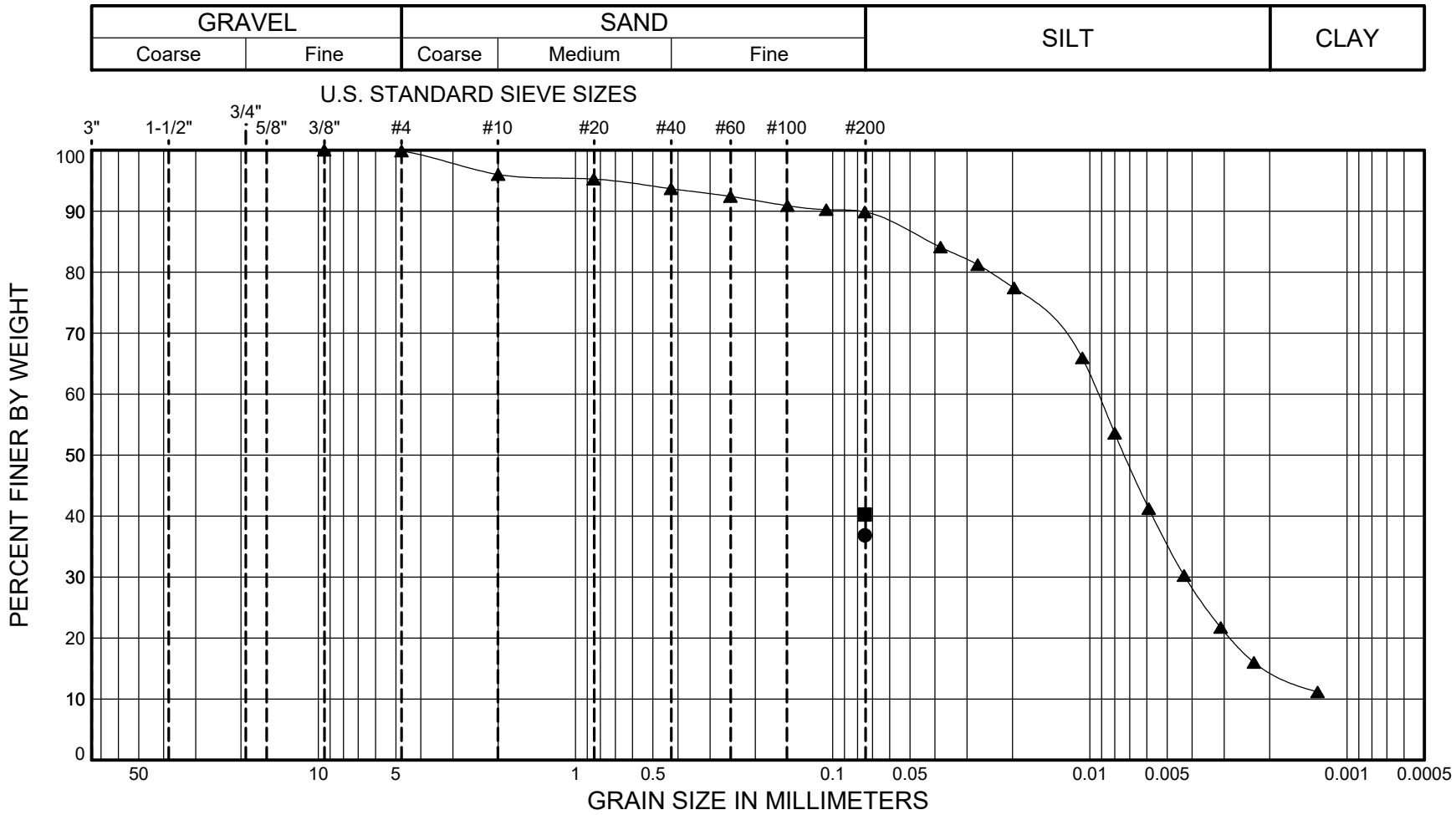
PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 22



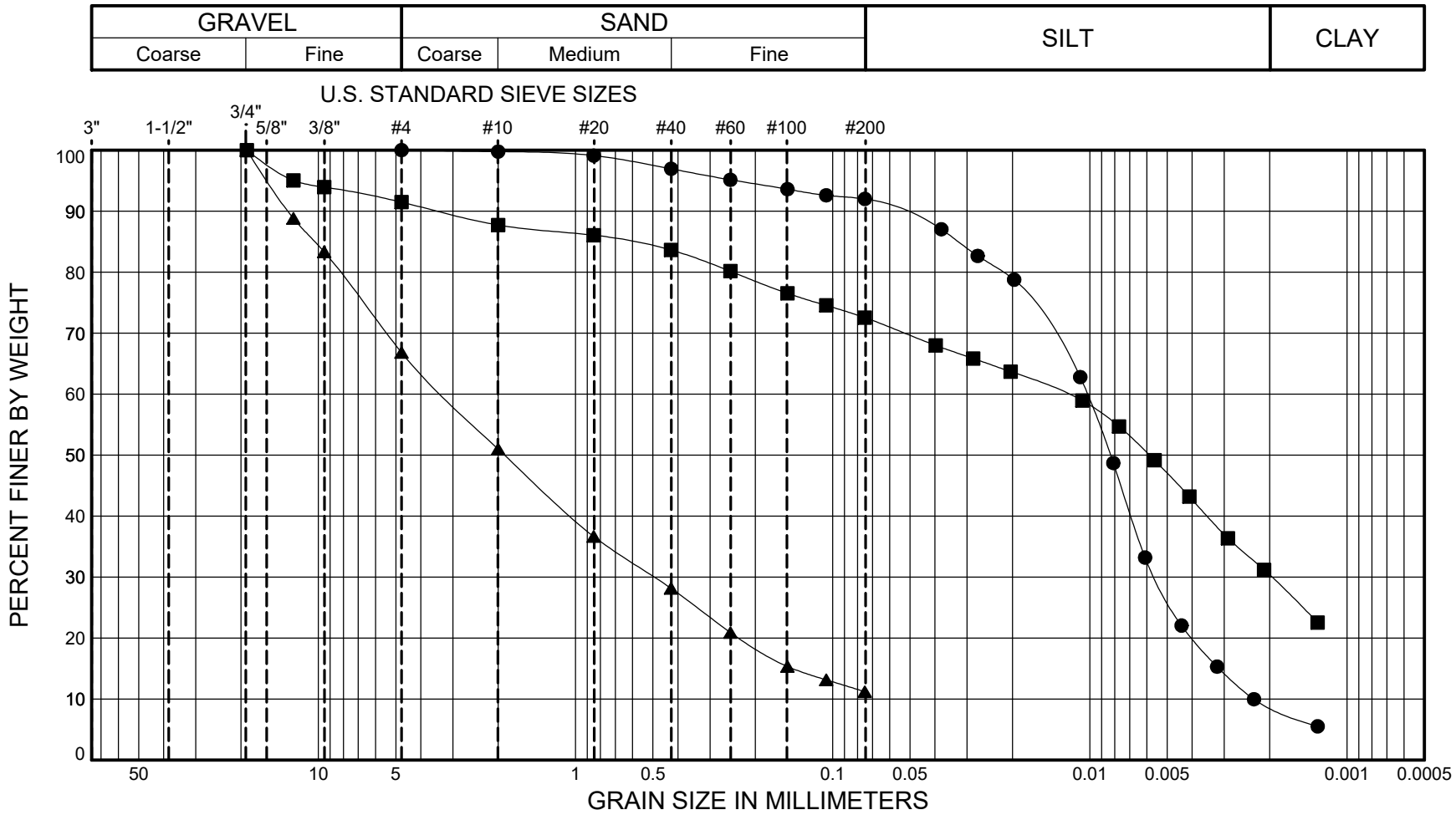
SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-217-20	S-3	7.5 - 8.8	(SM) Grayish-brown, silty SAND	9								36.8
■	W-217-20	S-5	15.0 - 16.0	(SM) Light brownish-gray, silty SAND	12								40.3
▲	W-217-20	S-7	25.0 - 26.5	(ML) Gray, SILT	23	48	30	18	0.1	10.0	75.1	14.8	

HWA GeoSciences Inc.

I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 23



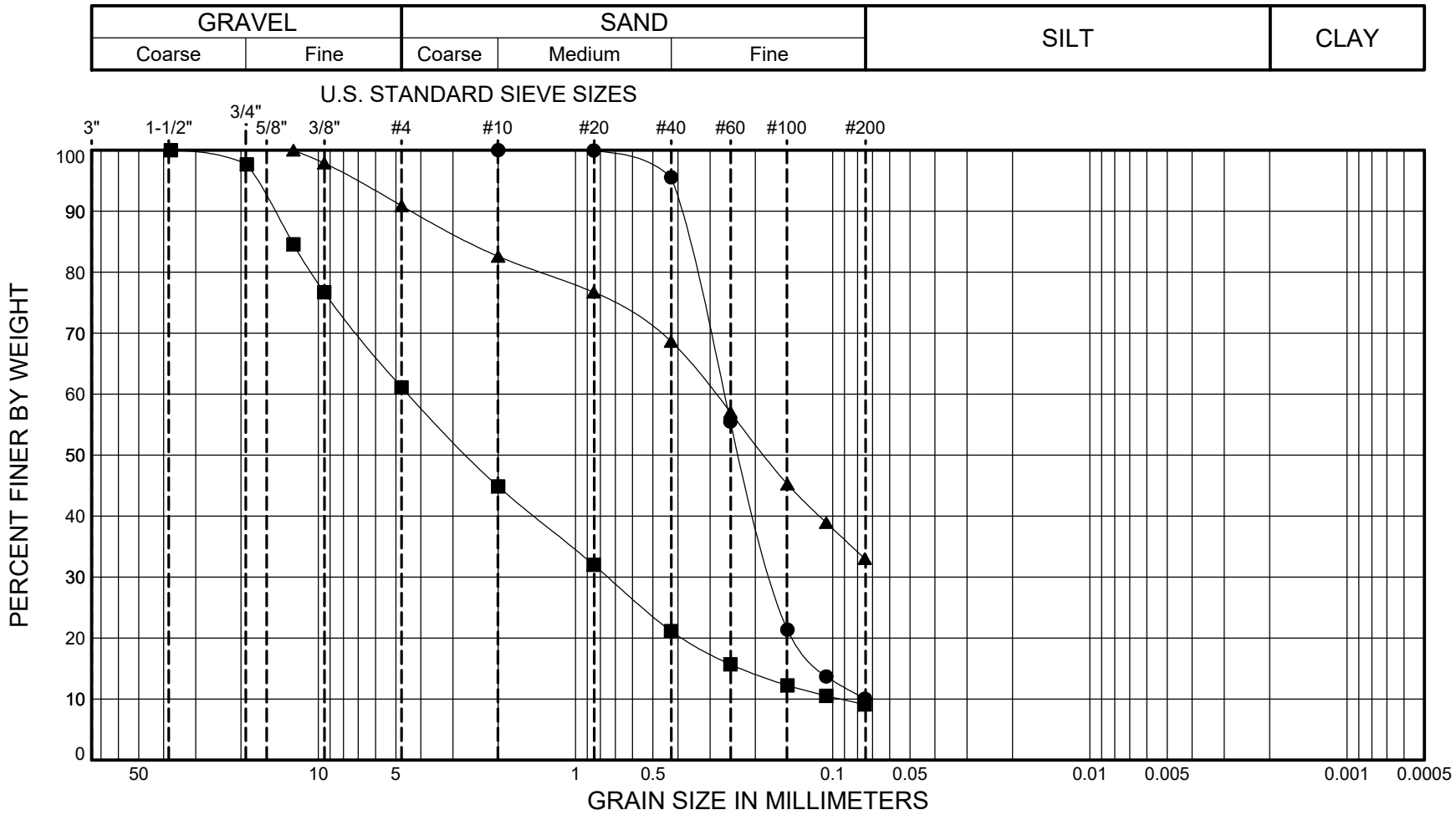
SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-217-20	S-9	35.0 - 36.5	(CL) Gray, lean CLAY	24	42	26	16		8.0	83.1	8.9	
■	W-217-20	S-10	40.0 - 41.0	(CH) Gray, fat CLAY with sand	15	56	28	28	8.5	18.9	42.2	30.3	
▲	W-217-20	S-12	50.0 - 50.8	(SW-SM) Grayish-brown, well-graded SAND with silt and gravel	5				33.2	55.6			11.2

HWA GeoSciences Inc.

I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 24



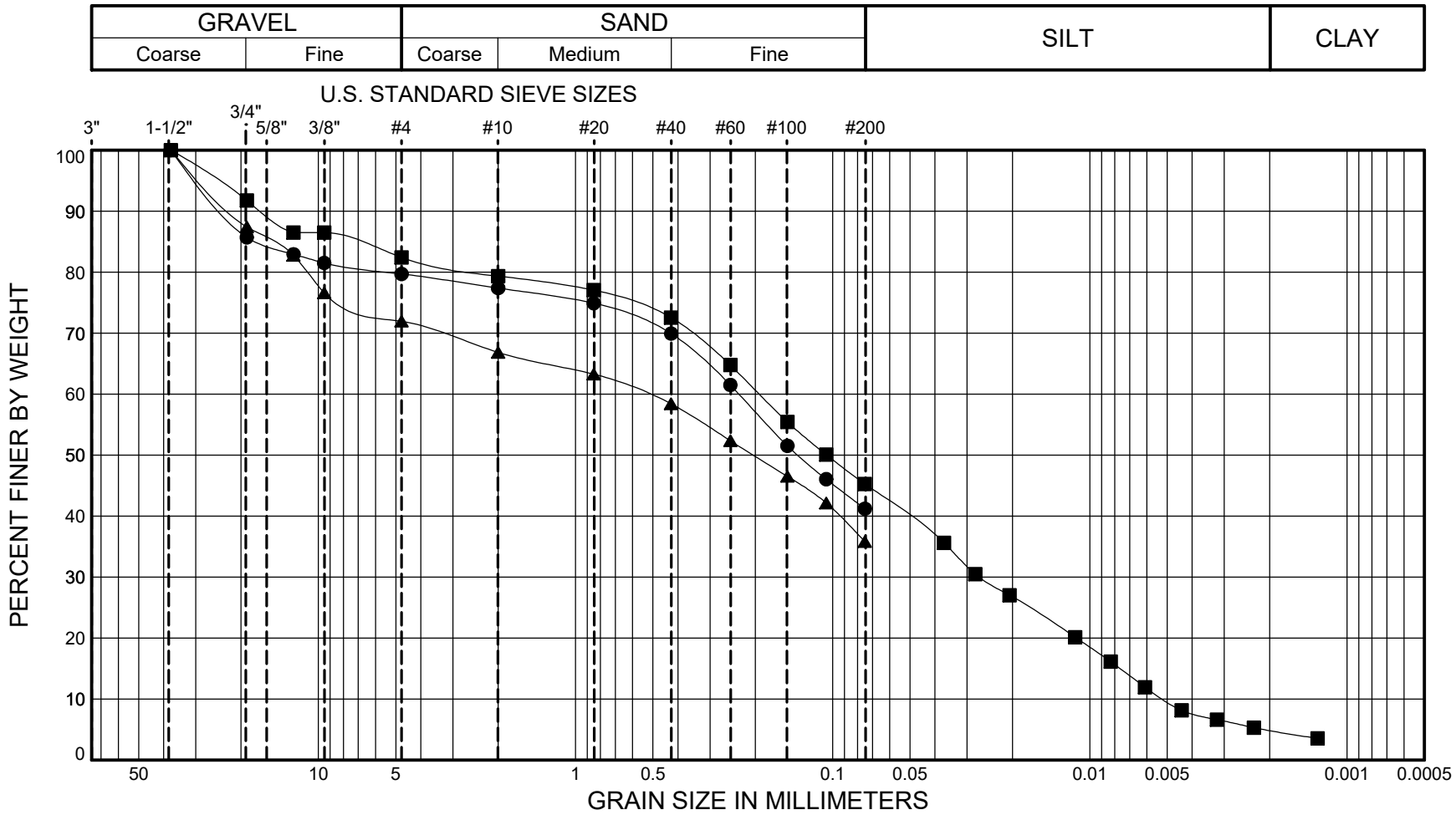
SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-216-20	S-6	20.0 - 21.5	(SP-SM) Grayish-brown, poorly graded SAND with silt	5					89.9			10.1
■	W-218-20	S-1	2.5 - 4.0	(SW-SM) Grayish-brown, well-graded SAND with silt and gravel	3				38.9	52.0			9.1
▲	W-218-20	S-3	7.5 - 9.0	(SM) Dark olive-brown, silty SAND	15				9.1	57.9			33.0

HWA GEOSCIENCES INC.

I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 13



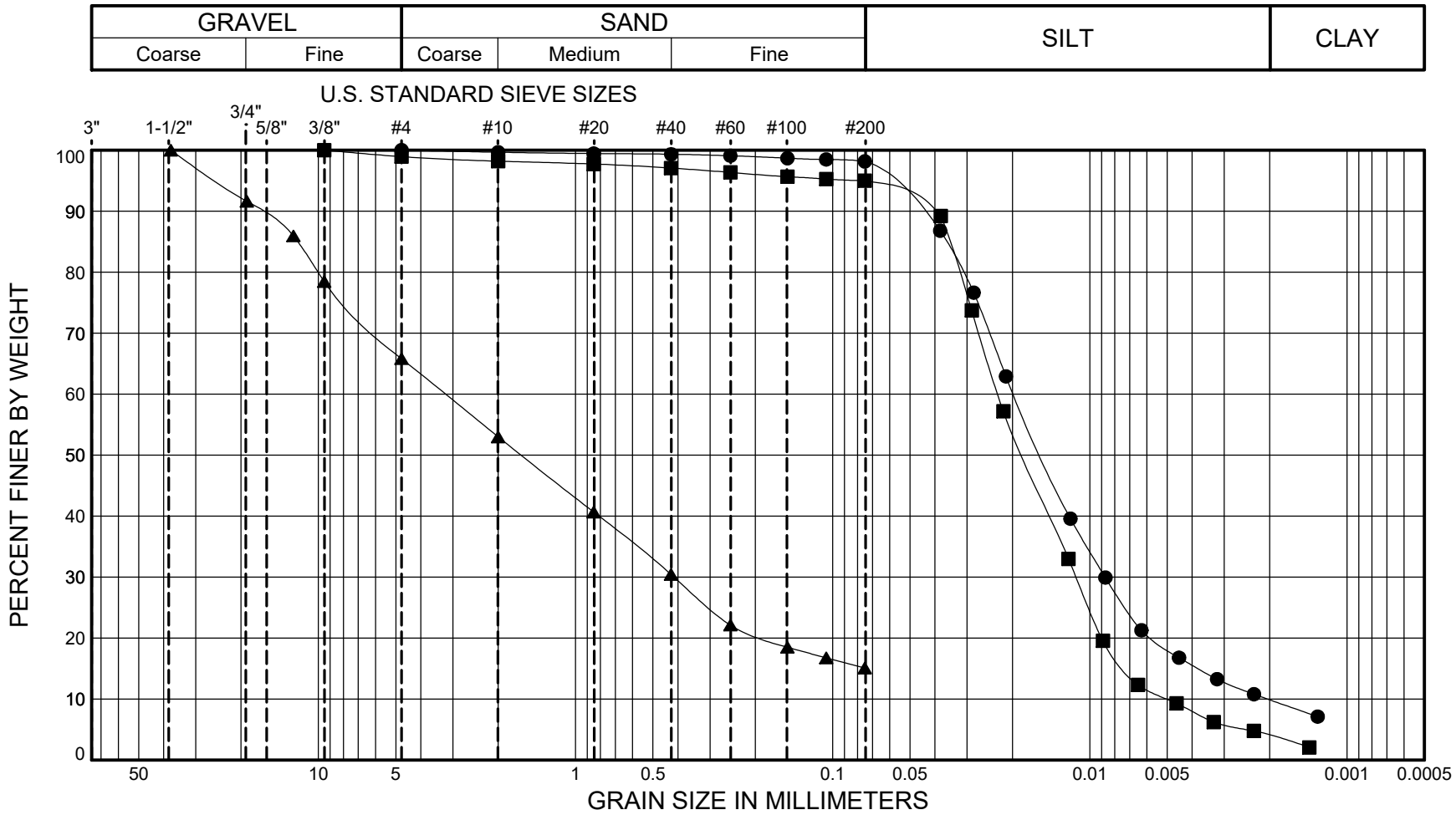
SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-218-20	S-5	15.0 - 16.5	(SM) Light olive-brown, silty SAND with gravel	11				20.3	38.5			41.2
■	W-218-20	S-6	20.0 - 21.0	(SM) Dark grayish-brown, silty SAND with gravel	10	17	14	3	17.6	37.1	40.4	4.9	
▲	W-218-20	S-8	30.0 - 30.5	(SM) Grayish-brown, silty SAND with gravel	5				28.1	36.1			35.8

HWA GeoSciences Inc.

I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 14



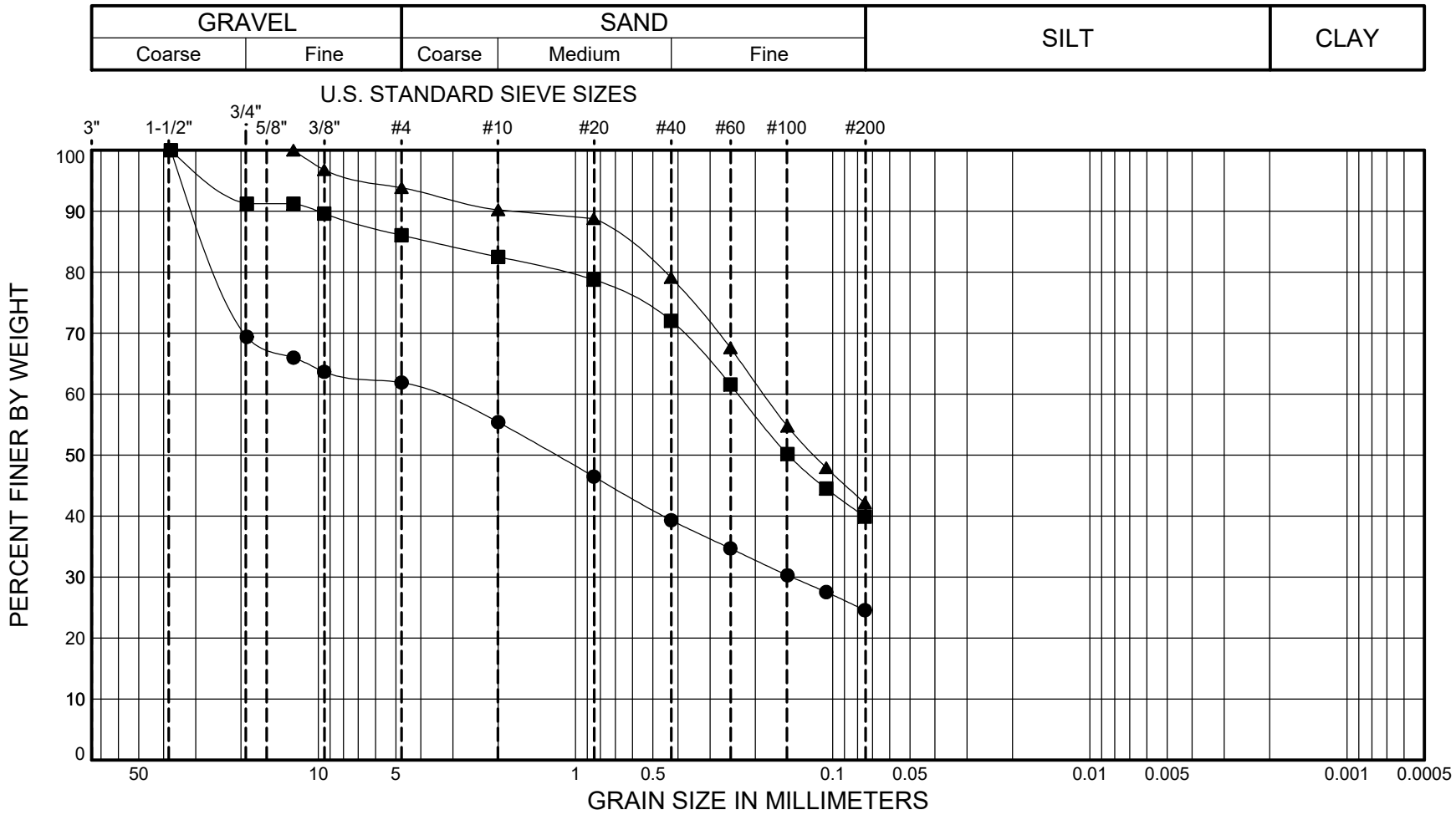
SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-218-20	S-11	45.0 - 46.0	(ML) Olive-brown, SILT	22	33	25	8		1.9	88.3	9.9	
■	W-218-20	S-13	55.0 - 56.0	(CL) Very dark gray, lean CLAY	25	36	23	13	1.1	3.9	91.0	4.0	
▲	W-218-20	S-15	65.0 - 65.5	(SM) Dark olive brown, silty SAND with gravel	8				34.2	50.7			15.1

HWA GeoSciences Inc.

I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 15



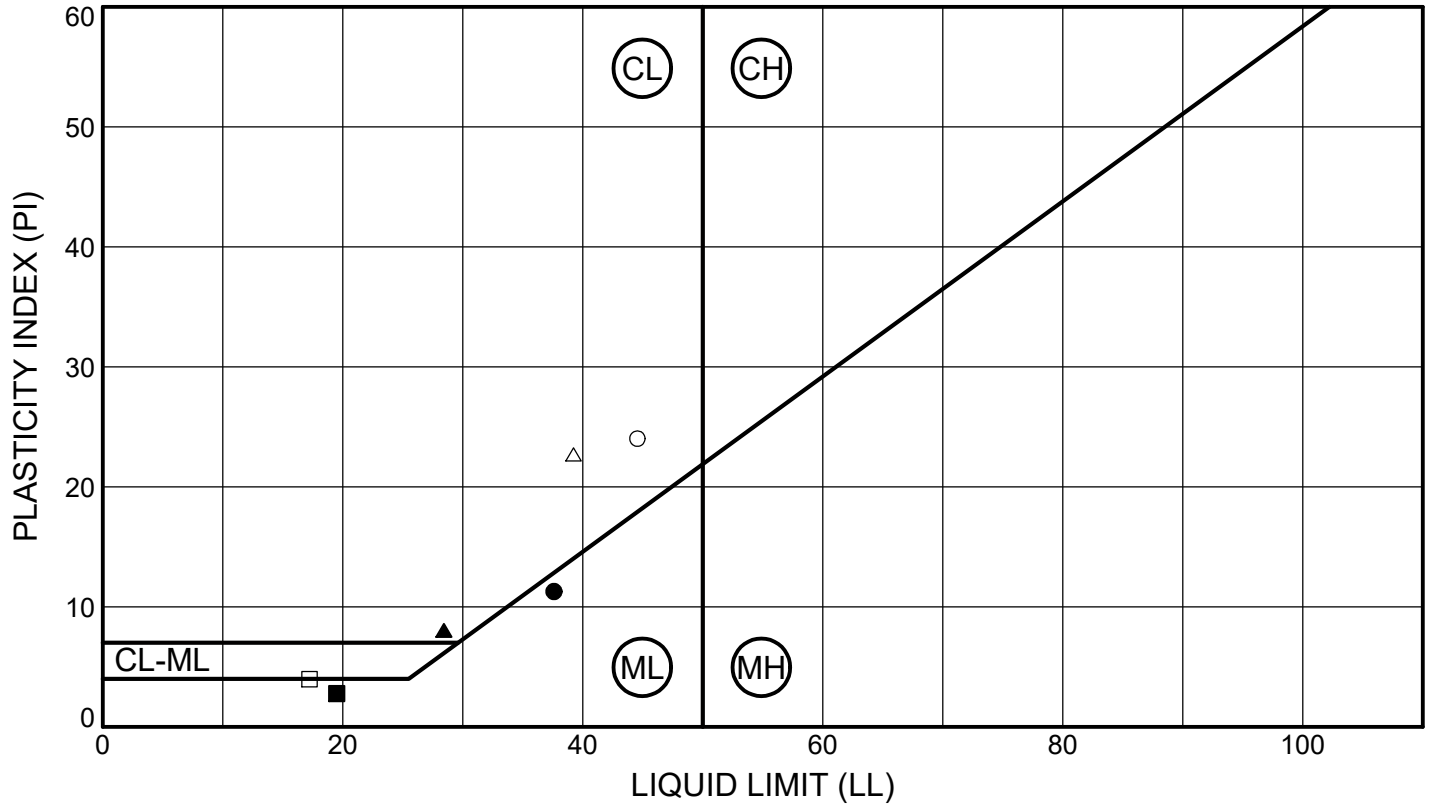
SYMBOL	SAMPLE		DEPTH (ft.)	ASTM SOIL CLASSIFICATION	% MC	LL	PL	PI	Gravel %	Sand %	Silt %	Clay %	Fines %
●	W-218-20	S-17	75.0 - 75.2	(GM) Dark grayish-brown, silty GRAVEL with sand	6				38.1	37.3			24.6
■	W-219-20	S-1	2.5 - 4.0	(SM) Light olive-brown, silty SAND	6				14.0	46.1			39.9
▲	W-219-20	S-3	7.5 - 9.0	(SM) Olive-brown, silty SAND	8				6.2	51.7			42.1

HWA GeoSciences Inc.

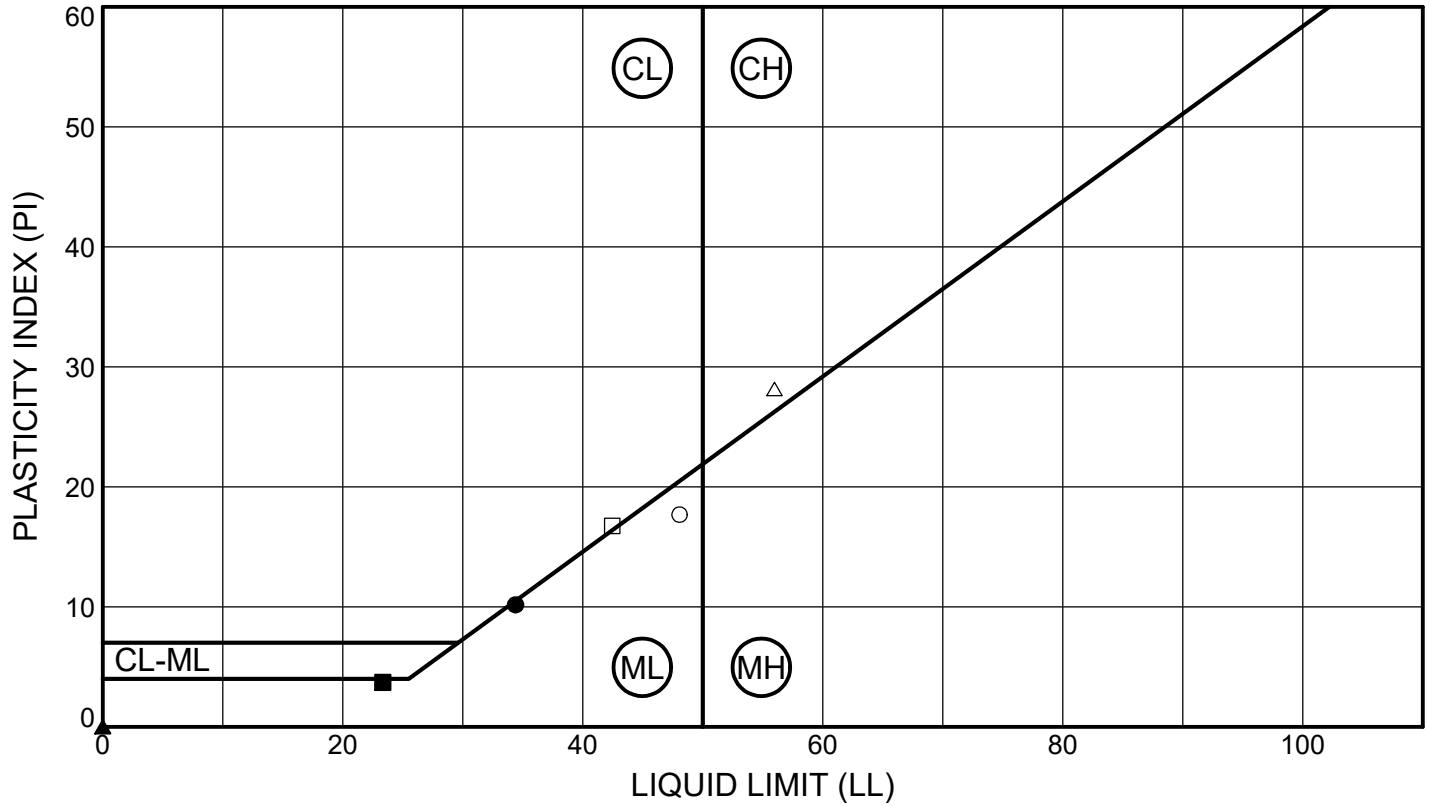
I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

PARTICLE-SIZE ANALYSIS
OF SOILS
METHOD ASTM D6913

PROJECT NO.: 2019-015-21 T200 FIGURE: 16



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	W-201-20	S-8	30.0 - 31.5	(ML) Grayish-brown, SILT	23	38	26	12	90.0
■	W-203-20	S-7	25.0 - 26.5	(SM) Olive-brown, silty SAND with gravel	11	19	17	2	30.1
▲	W-207-20	S-5	15.0 - 16.5	(CL) Olive-brown, sandy lean CLAY with gravel	17	28	20	8	50.1
○	W-208-20	S-8B	30.0 - 31.5	(CL) Gray, lean CLAY with sand	30	45	21	24	78.2
□	W-208-20	S-9	35.0 - 36.5	(SC-SM) Olive-brown, silty, clayey SAND	10	17	13	4	42.9
△	W-214-20	S-1	2.5 - 4.0	(SC) Olive-brown, clayey SAND	10	39	17	22	47.3



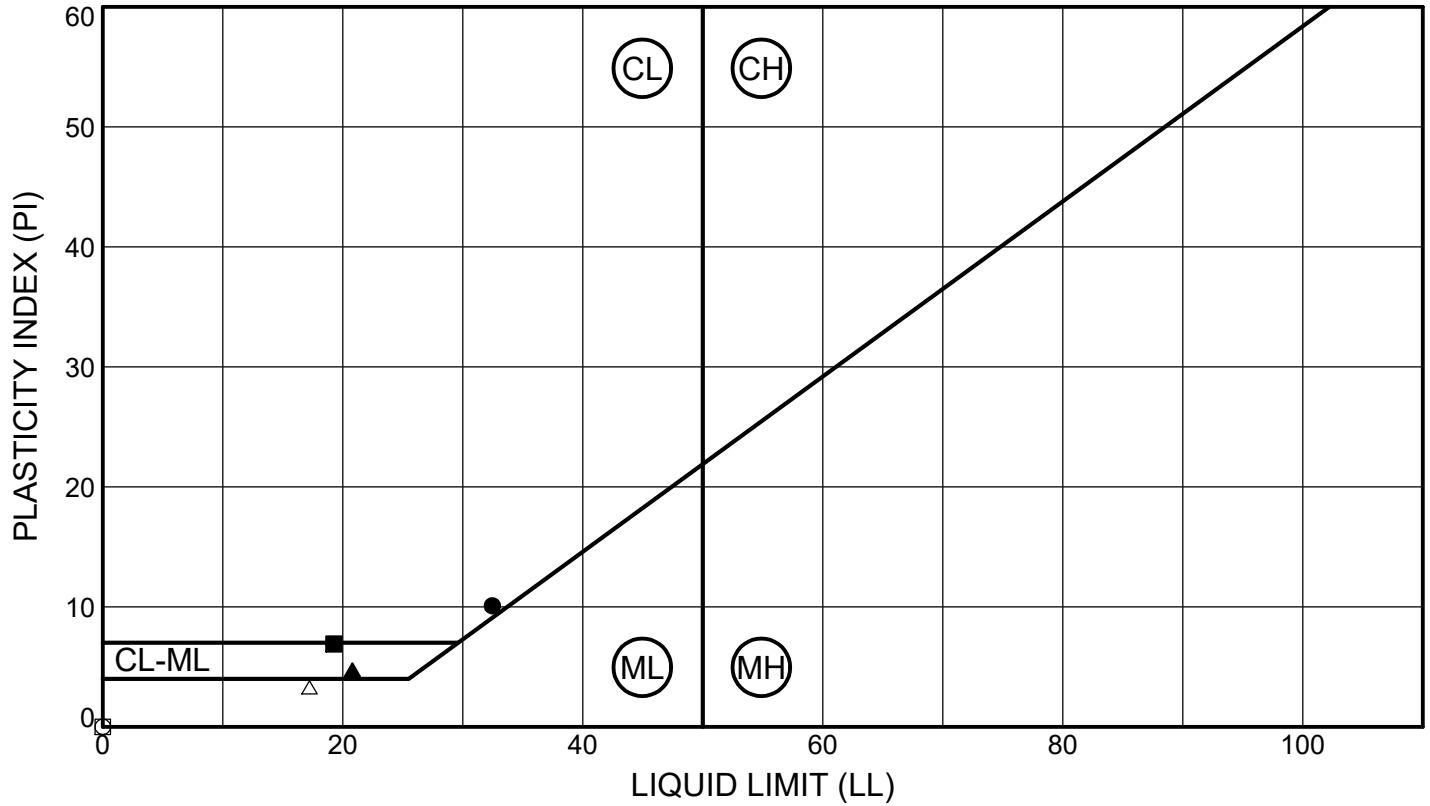
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	W-214-20	S-4	10.0 - 11.5	(GM) Olive-brown, silty GRAVEL with sand	11	34	24	10	14.5
■	W-214-20	S-9	35.0 - 36.5	(ML) Light olive-brown, sandy SILT	21	23	20	3	60.7
▲	W-215-20	S-5B	16.0 - 16.5	(ML) Light olive-brown, SILT with sand	19	NP	NP	NP	71.9
○	W-217-20	S-7	25.0 - 26.5	(ML) Gray, SILT	23	48	30	18	89.9
□	W-217-20	S-9	35.0 - 36.5	(CL) Gray, lean CLAY	24	42	26	16	92.0
△	W-217-20	S-10	40.0 - 41.0	(CH) Gray, fat CLAY with sand	15	56	28	28	72.5

HWA GeoSciences Inc.

I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

LIQUID LIMIT, PLASTIC LIMIT AND
PLASTICITY INDEX OF SOILS
METHOD ASTM D4318

PROJECT NO.: 2019-015-21 T200 FIGURE: 30



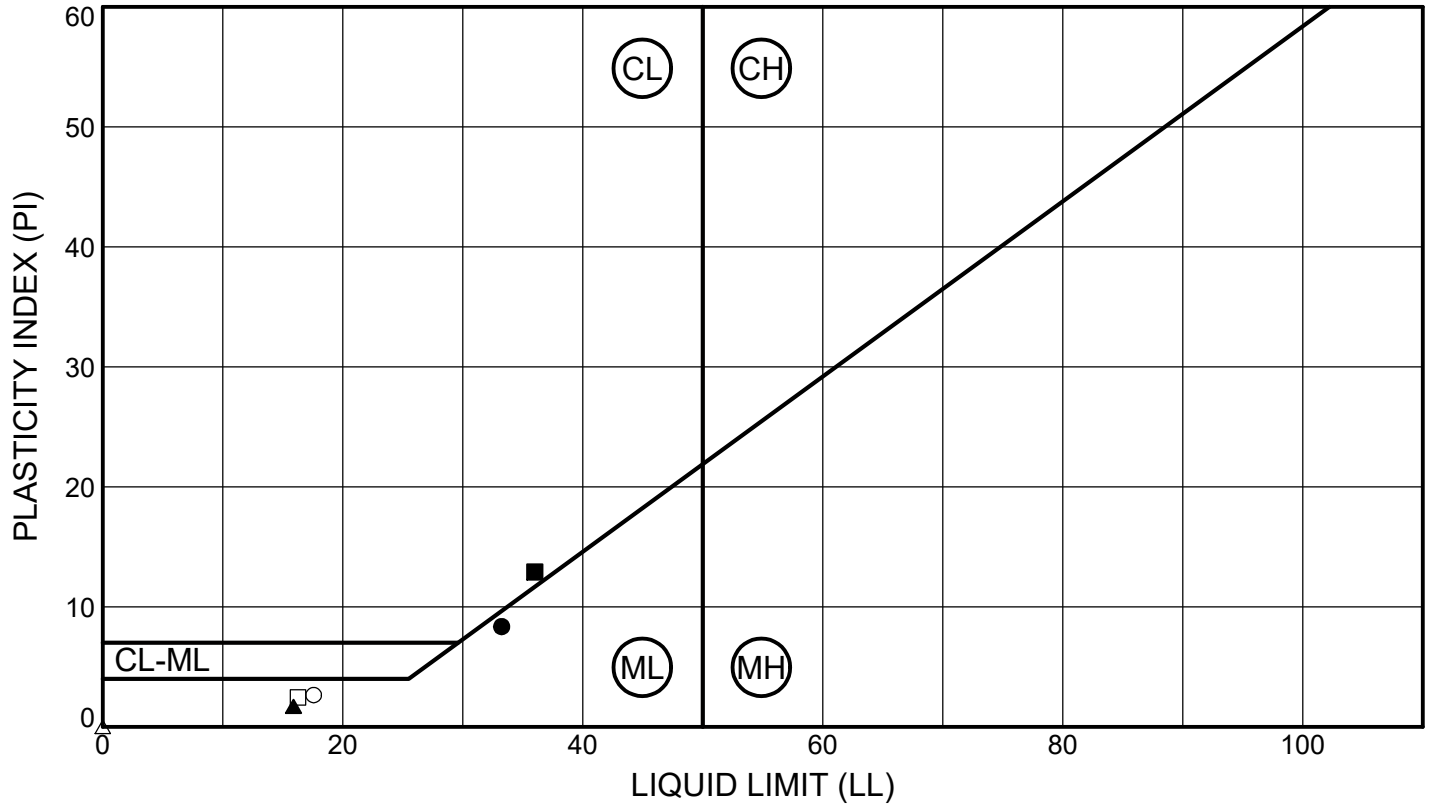
SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	W-205-20	S-5	15.0 - 16.5	(CL) Very dark gray, lean CLAY	19	32	22	10	93.0
■	W-206-20	S-2	5.0 - 6.5	(SC-SM) Dark gray, silty, clayey SAND with gravel	11	19	12	7	48.8
▲	W-206-20	S-4B	10.0 - 11.0	(CL-ML) Gray, sandy silty CLAY	12	21	16	5	59.6
○	W-206-20	S-7A	25.0 - 26.5	(SM) Dark grayish-brown, silty SAND	22	NP	NP	NP	36.8
□	W-206-20	S-8	30.0 - 31.5	(ML) Olive, SILT with sand	24	NP	NP	NP	80.9
△	W-218-20	S-6	20.0 - 21.0	(SM) Dark grayish-brown, silty SAND with gravel	10	17	14	3	45.3

GeoSciences Inc.

I-405 Renton to Bellevue
Widening and Express Toll Lanes
Client Project No.: PS19203160

LIQUID LIMIT, PLASTIC LIMIT AND
PLASTICITY INDEX OF SOILS
METHOD ASTM D4318

PROJECT NO.: 2019-015-21 T200 FIGURE: 28



SYMBOL	SAMPLE		DEPTH (ft)	CLASSIFICATION	% MC	LL	PL	PI	% Fines
●	W-218-20	S-11	45.0 - 46.0	(ML) Olive-brown, SILT	22	33	25	8	98.1
■	W-218-20	S-13	55.0 - 56.0	(CL) Very dark gray, lean CLAY	25	36	23	13	95.0
▲	W-220-20	S-3	7.5 - 9.0	(SM) Dark olive-brown, silty SAND	8	16	14	2	36.7
○	W-222-20	S-12	50.0 - 51.0	(ML) Olive-brown, sandy SILT	15	18	15	3	61.1
□	W-222-20	S-13	55.0 - 55.5	(SM) Dark gray, silty SAND	14	16	14	2	44.4
△	W-222-20	S-17	75.0 - 76.0	(ML) Dark gray, sandy SILT	21	NP	NP	NP	51.3

Job No. **XL-4653** Date **May 7, 2018**

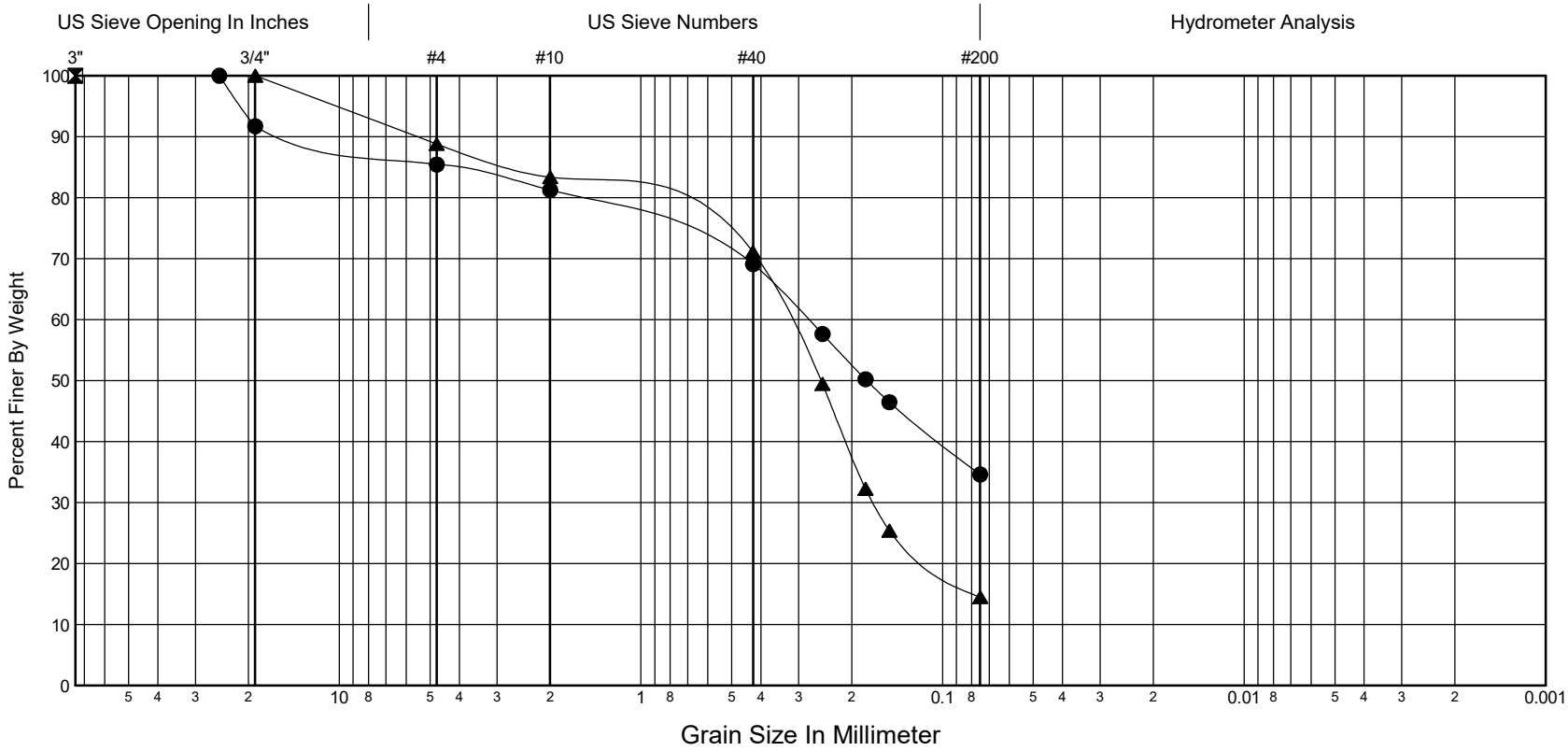
Hole No. **R2B-10-17** Sheet **1**

Project **I-405 Renton to Bellevue - ETL - Envir & Traff**

Laboratory Summary

WSDOT

	Depth (ft)	Sample No.	USCS	Description	MC%	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	Cc	Cu	D60	D50	D30	D20	D10
●	7.0	D-2	SM	SILTY SAND	19	19	NP	NA			14.6	50.8	34.6			0.279	0.18			
⧓	12.0	D-4		MC & LOI Only	33															
▲	24.0	D-7		MC & Sieve Only	18						11.2	74.3	14.5			0.324	0.25	0.17	0.11	



Gravel	Sand			Silt			Clay
	Coarse	Medium	Fine	Coarse	Medium	Fine	

XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ PUBLIC-COMMON LIBRARY.GLB 5/7/18

Job No. **XL-4653** Date **May 7, 2018**

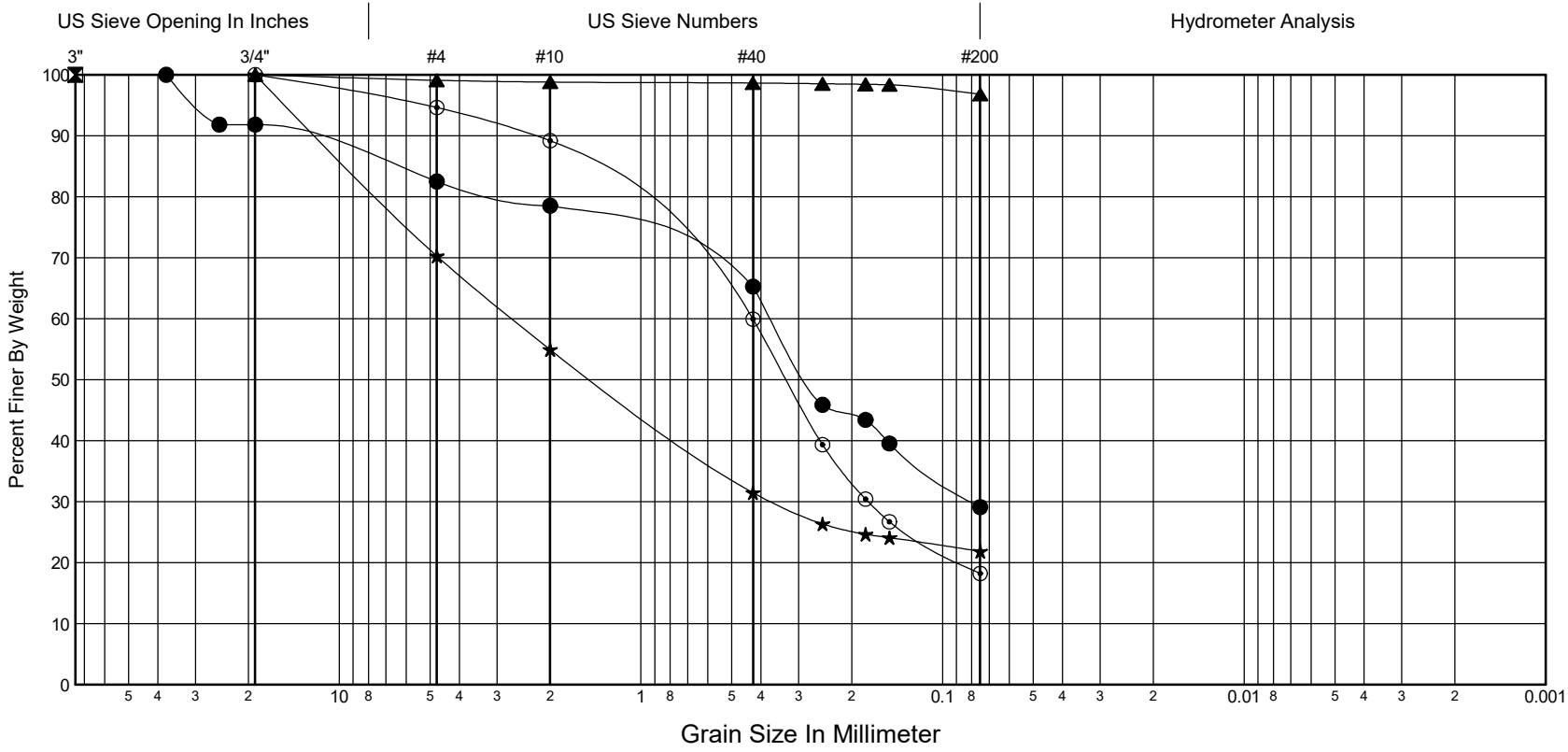
Hole No. **R2B-11-17** Sheet **1**

Project **I-405 Renton to Bellevue - ETL - Envir & Traff**

Laboratory Summary

WSDOT

	Depth (ft)	Sample No.	USCS	Description	MC%	LL	PL	PI	Moist Density (lbs/ft^3)	Specific Gravity	Gravel (%)	Sand (%)	Fines (%)	Cc	Cu	D60	D50	D30	D20	D10
●	7.0	D-2	SM	SILTY SAND with GRAVEL and Organics	15	18	NP	NA			17.5	53.4	29.1			0.368	0.28	0.08		
⧓	14.0	D-5		MC & LOI Only	32															
▲	24.0	D-7	ML	SILT	31	31	28	3			0.9	2.3	96.8							
★	34.0	D-9	SC	CLAYEY SAND with GRAVEL	11	31	22	9			29.7	48.5	21.8			2.661	1.44	0.36		
⊙	54.0	D-13		MC & Sieve Only	17						5.4	76.4	18.2			0.426	0.33	0.18	0.09	



Gravel	Sand			Silt			Clay
	Coarse	Medium	Fine	Coarse	Medium	Fine	

XL-5467 (OLD XL-4653) 405 RENTON TO BELLEVUE ETL - ENVIRO AND TRAFF.GPJ PUBLIC-COMMON LIBRARY.GLB 5/7/18

Washington State Department of Transportation
State Materials Laboratory
PO Box 47365 Olympia WA 98504 / 1655 S. 2nd Ave Tumwater WA 98512

Miscellaneous Report

Work Order :	XL4653	**Sample ID :**	0000012011e
Section :	I-405/Renton To Bellevue-Express Toll Lanes-Envir&Traff		
State Route No :		**Lab Number :**	MC0170045
Project Engineer :	Jason Qiu	**Bid Item No :**	
Org Code :	412335	**Date Received :**	5/25/2017
		Local Agency No :	

Material :	Soils		
Contractor :		**Pit Number :**	R2B-10-17
Supplier Name :		**Date Sampled :**	5/24/2017
Acceptance No :		**Date Received :**	5/25/2017
Sampled Location :	12.0' to 13.5'	**Sampled By :**	Drill Crew
Make :		**IAS Sample No :**	D-4
Manufacturer :		**Lot Number :**	

Test Name	Test Result	Test Specifications
AASHTO T267 Determination of Organic Content in Soils by Loss on Ignition	7.23%	AASHTO T267

Result Code: Informational

Remarks : Boring: R2B-10-17
Sample: D-4
Depth: 12.0' to 13.5'
Lab #: G-1408

Kurt R. Williams, P.E.
State Materials Engineer
Katharine Dafoe By:_____
Chemistry Laboratory Supervisor
Date : 5/30/2017
Phone : (360) 709-5537

Billing Code
T2D1 - 1
T2M6 - 1

Washington State Department of Transportation
State Materials Laboratory
PO Box 47365 Olympia WA 98504 / 1655 S. 2nd Ave Tumwater WA 98512

Miscellaneous Report

Work Order :	XL4653	**Sample ID :**	0000012013e
Section :	I-405/Renton To Bellevue-Express Toll Lanes-Envir&Traff		
State Route No :		**Lab Number :**	MC0170046
Project Engineer :	Jason Qiu	**Bid Item No :**	
Org Code :	412335	**Date Received :**	5/25/2017
		Local Agency No :	

Material :	Soils		
Contractor :		**Pit Number :**	R2B-11-17
Supplier Name :		**Date Sampled :**	5/24/2017
Acceptance No :		**Date Received :**	5/25/2017
Sampled Location :	14.0' to 15.5'	**Sampled By :**	Drill Crew
Make :		**IAS Sample No :**	D-5
Manufacturer :		**Lot Number :**	

Test Name	Test Result	Test Specifications
AASHTO T267 Determination of Organic Content in Soils by Loss on Ignition	7.32%	AASHTO T267

Result Code: Informational

Remarks : Boring: R2B-11-17
Sample: D-5
Depth: 14.0' to 15.5'
Lab #: G-1409
Report Revised to correct the Boring/Pit number.

Kurt R. Williams, P.E.
State Materials Engineer
Katharine Dafoe By:_____
Chemistry Laboratory Supervisor
Date : 6/1/2017
Phone : (360) 709-5537

Billing Code
T2D1 - 1
T2M6 - 1

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Seattle

Date February 25, 1985

Dear Sir:

DISTURBED

I have forwarded by today's Hand Carried the following Foundation Samples.

Contract or Job No. C-2637

Section Sunset Blvd. to Factoria
SR No. 405 Sub-Section

Station & Offset 377+44 109' LT ℄

Hole # 1

E Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
5991-1	P-1	-1.0' to -3.0'	H20= 12.3	SM	
-2	P-2	-3.0' to -5.0'	H20= 12.8	SM	
-3	P-3	-5.0' to -7.0'	H20= 16.2	SM	
-4	P-4	-7.5' to -9.5'	H20= 18.7	SM	
-5	P-5	-10.0' to -12.0'	H20= 15.7	SM	
-6	P-6	-12.5' to -14.5'	H20= 43.1	SM	
-7	P-7	-15.0' to -16.5'	H20= 10.1	SP SM	
-8	P-8	-17.5' to -18'9"	H20= 24.3	SP SM	
-9	P-9	-20.0' to -20'3"			LKS881-8

1 copy with samples
1 copy to addressee

Yours very truly,

KEW (RMM)

Inspector.

DOT FORM 351-002 REVISED 2/80

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Seattle

Date February 25, 1985

Dear Sir:

DISTURBED

I have forwarded by today's Hand Carried the following Foundation Samples.

Contract or Job No. C-2637 Section Sunset Blvd. to Factoria I/C SR No. 405 Sub-Section

Station & Offset 377+44 109' LT ℄ Hole # 1

E Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
5201-10	P-10	-25.0' to -25'3"	H20 = 9.9	SP SM	

1 copy with samples
1 copy to addressee

Yours very truly,

KEW (RMM)

Inspector.

DOT FORM 351-002 REVISED 2/80

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5881-1 JOB NO. C2637 HOLE NO. 1
DATE 4-17-85 OPERATOR BD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	~	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

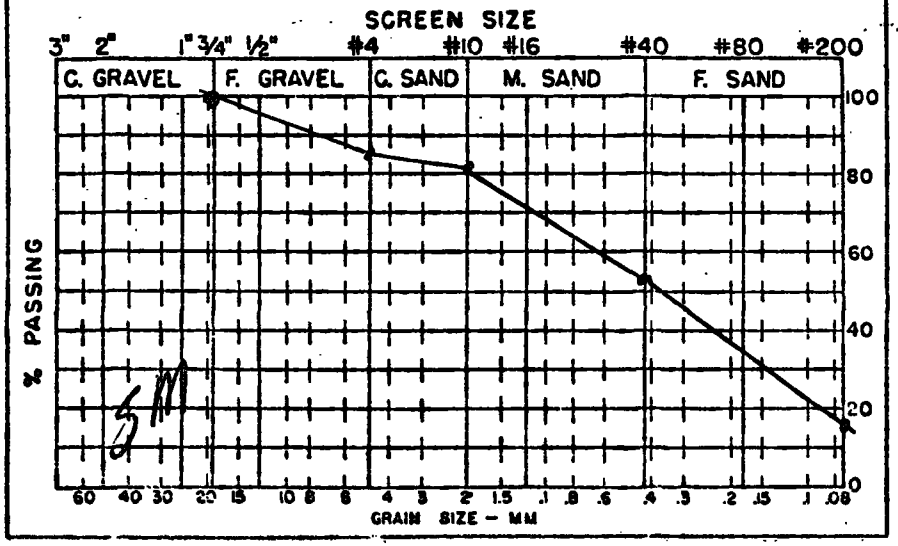
DESCRIPTION: Brn, moist, F Gravelly, Slty, C-M-F SAND

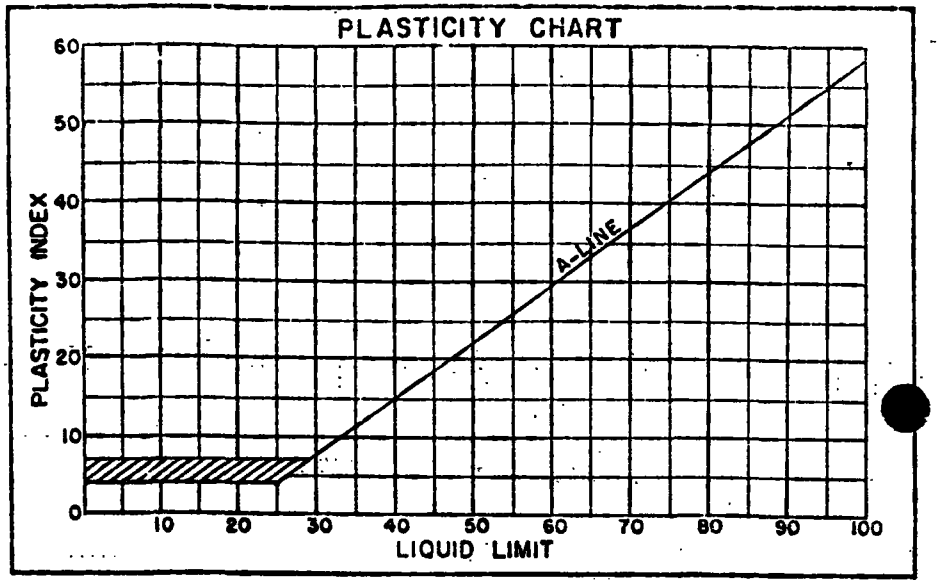
39.6 44.5 12.3

SIEVE ANALYSIS % Passing 188.6

		-40	62.6	52.2
-¾	29.35	100	-80	
-4	5.9	83.8	-140	
-10	51.6	80.6	-200 32.15	17.7

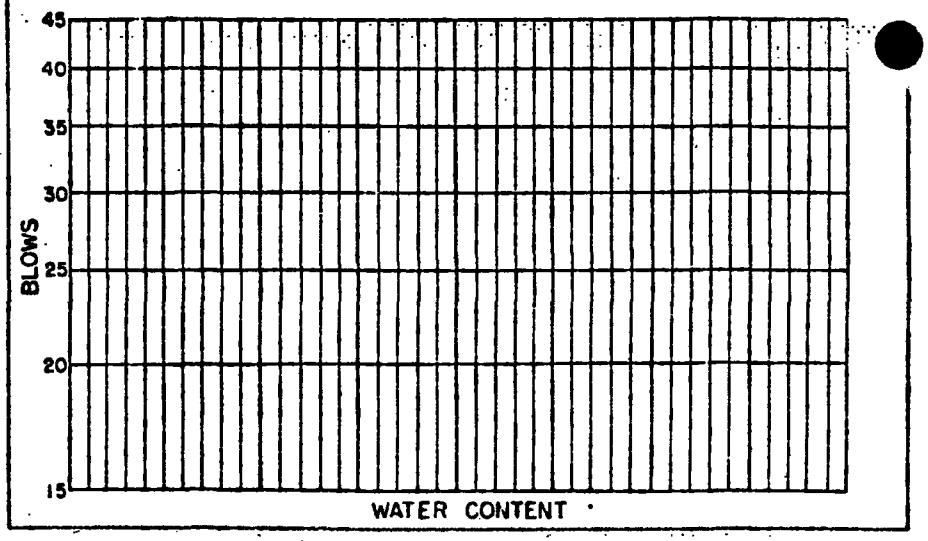
GRAIN SIZE CURVE





LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

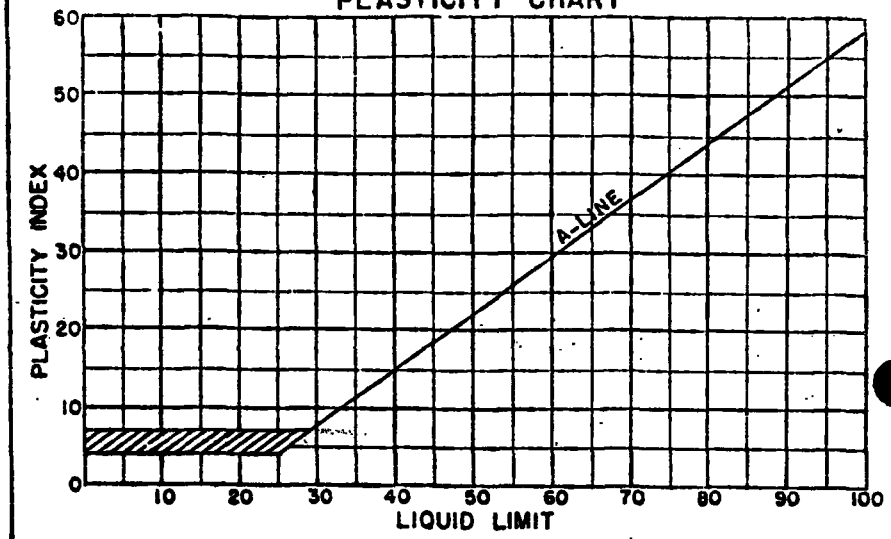
SAMPLE NO. 5881-2 JOB NO. C2637 HOLE NO. 1
DATE 4-17-85 OPERATOR [illegible]

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Br, moist, F Gravelly, SLTY, SLYC; M-F SAND

PLASTICITY CHART

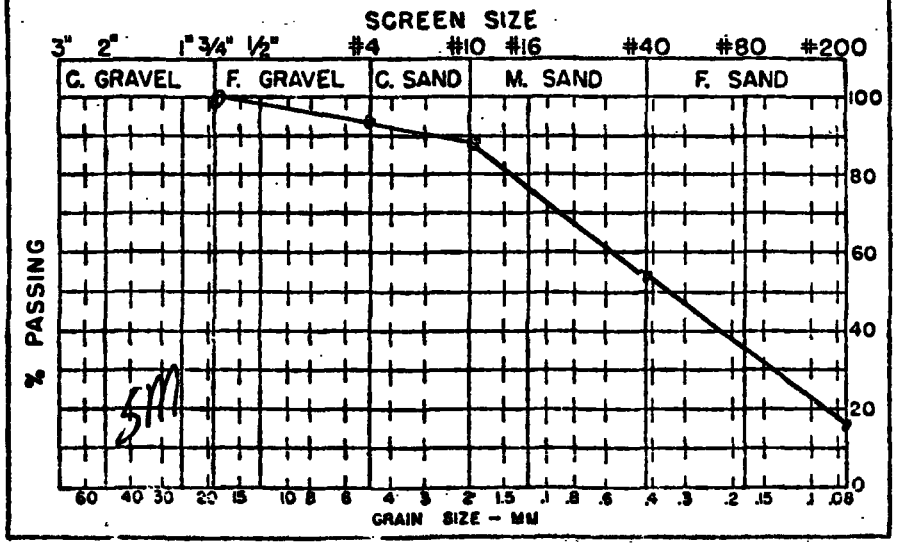


33.6 37.9 12.8

SIEVE ANALYSIS % Passing 154.55

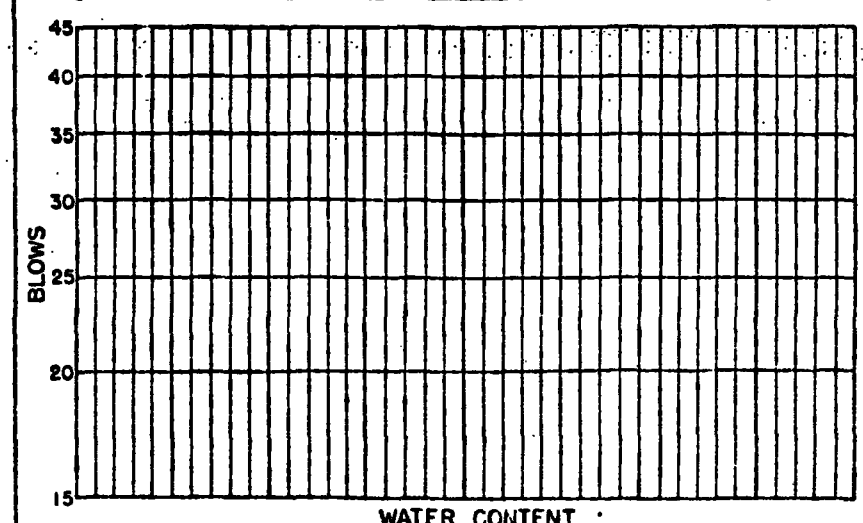
		-40 53.85	53.1
-3/4 9.9	100	-80	
-4 7.15	93.5	-140	
-10 55.4	88.9	-200 28.25	18.3

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



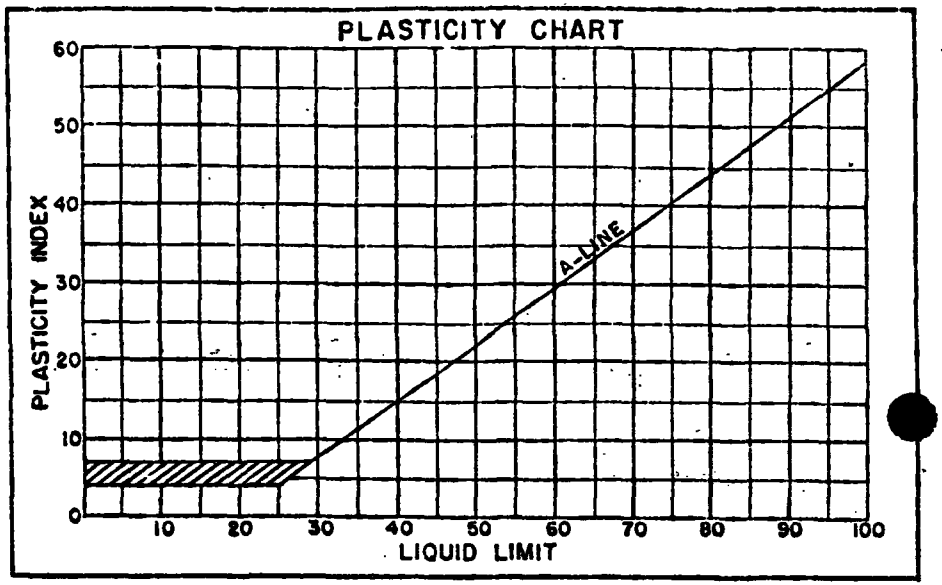
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5881-3 JOB NO. C2637 HOLE NO. 1
DATE 4-17-85 OPERATOR SD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Br moist, F Gravelly VSLTY, C-M-F SAND

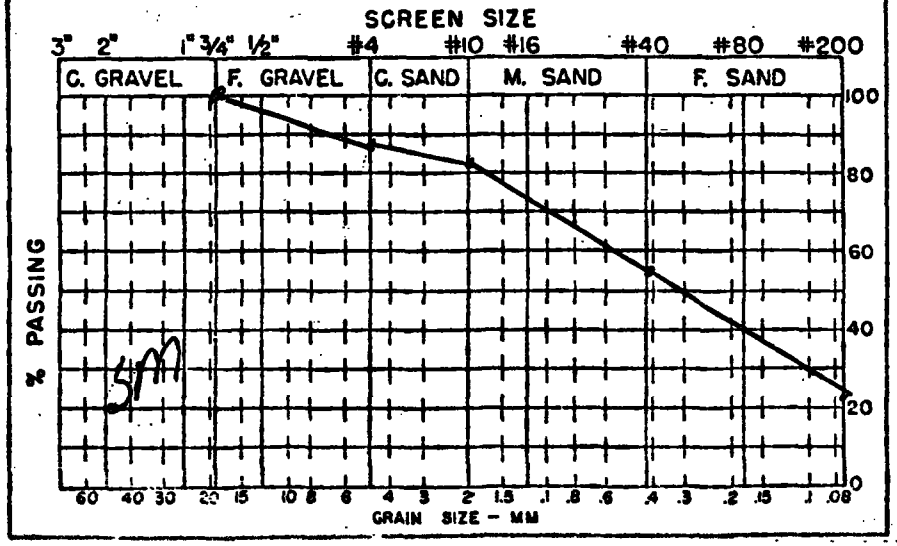


46.0 53.45 16.2

SIEVE ANALYSIS % Passing 105.6

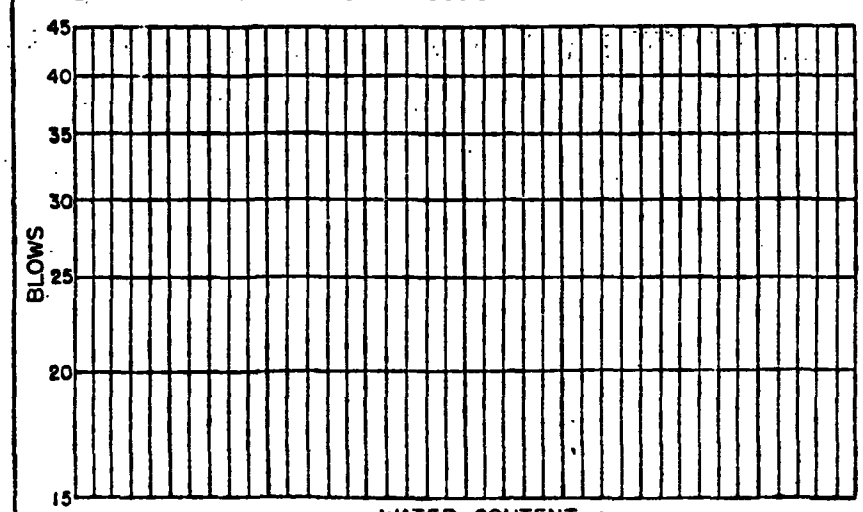
			-40	34.5	54.5
-3/4	11.6	100	-80		
-4	8.2	88.9	-140		
-10	28.2	81.2	-200	23.1	21.8

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. S88-4 JOB NO. 2637 HOLE NO. 1

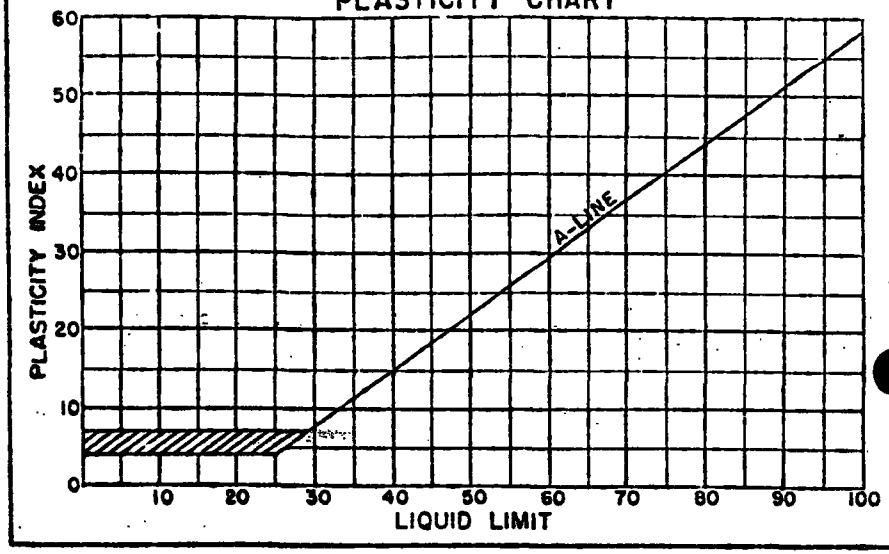
DATE 4-17-85 OPERATOR BD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Br, moist, F Gravelly, V Slty, C, M-F SAND

PLASTICITY CHART

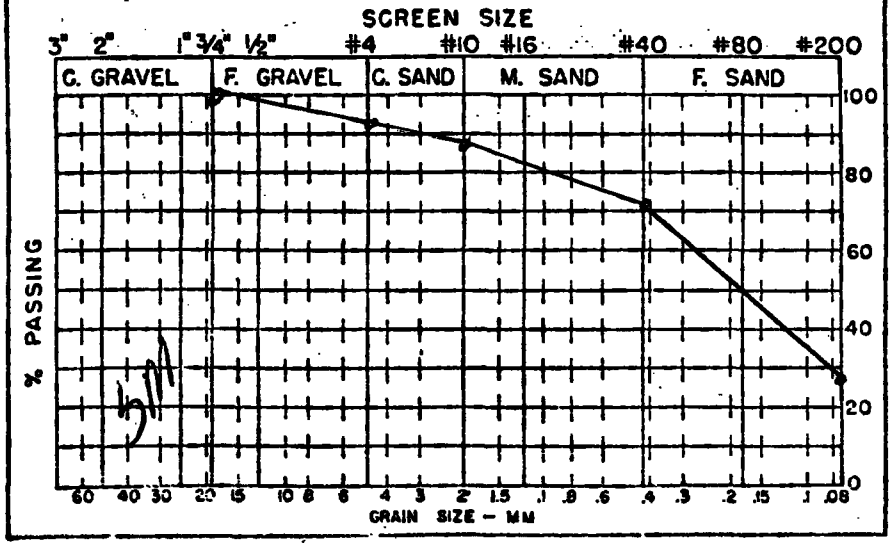


44.2 52.5 18.7

SIEVE ANALYSIS % Passing 15.7

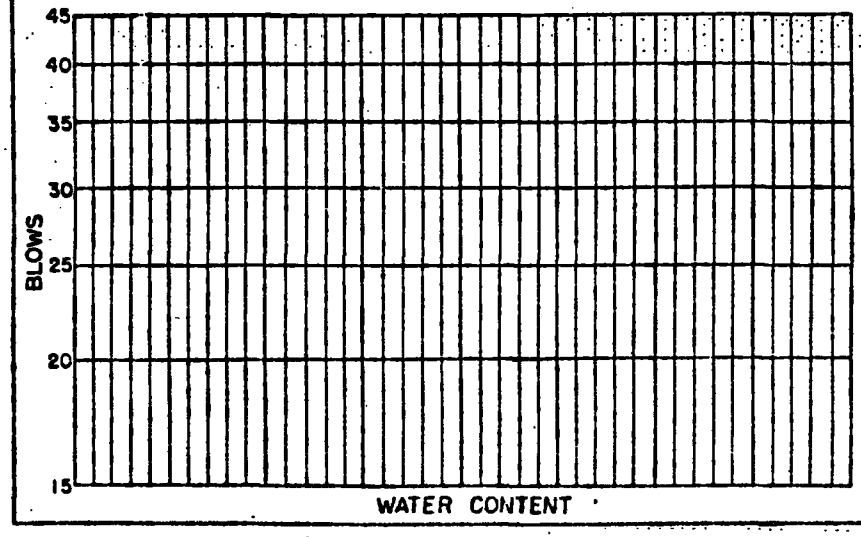
		-40	64.1	20.4
-¾	12.7	100	-80	
-4	3.1	91.5	-140	
-10	28.55	89.5	-200 42.85	28.2

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

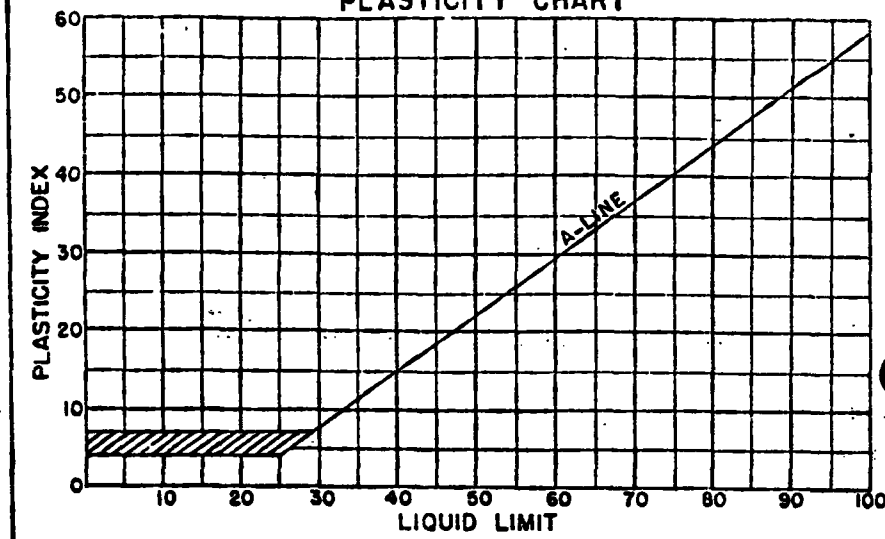
SAMPLE NO. 5881-5 JOB NO. C2637 HOLE NO. 1
DATE 4-17-85 OPERATOR SD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, SILTY, C-F Gravelly, C-M-F SAND

PLASTICITY CHART

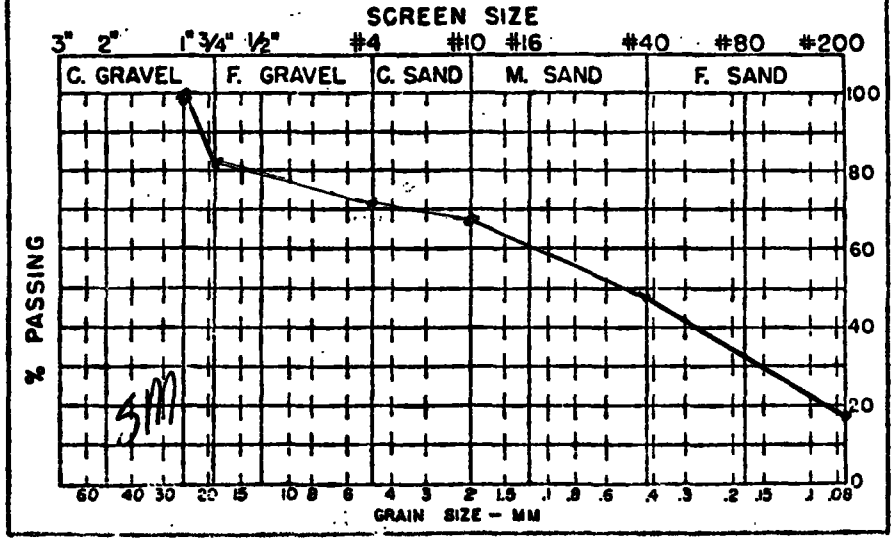


33.8 39.1 16.7

SIEVE ANALYSIS % Passing 173.15

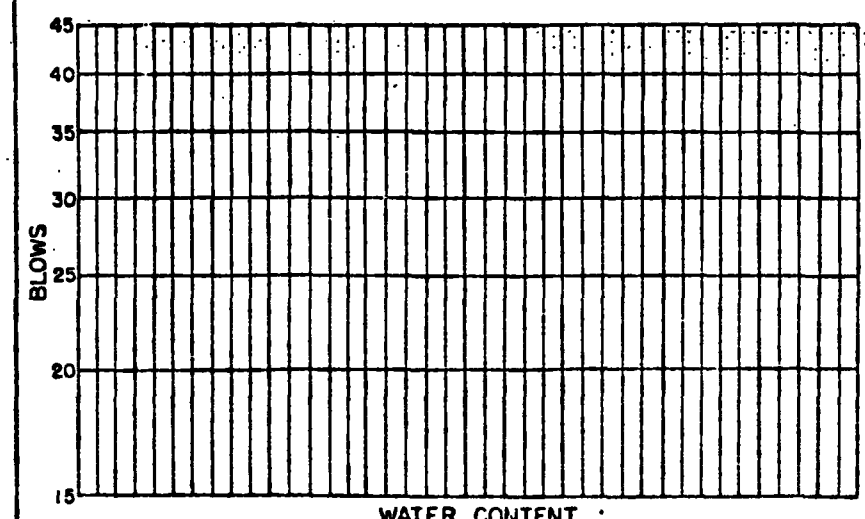
-131.5	100	-40	53.25	49.1
-3/4 18.55	81.8	-80		
-4 5.1	71.1	-140		
-10 33.1	68.2	-200	31.65	18.3

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

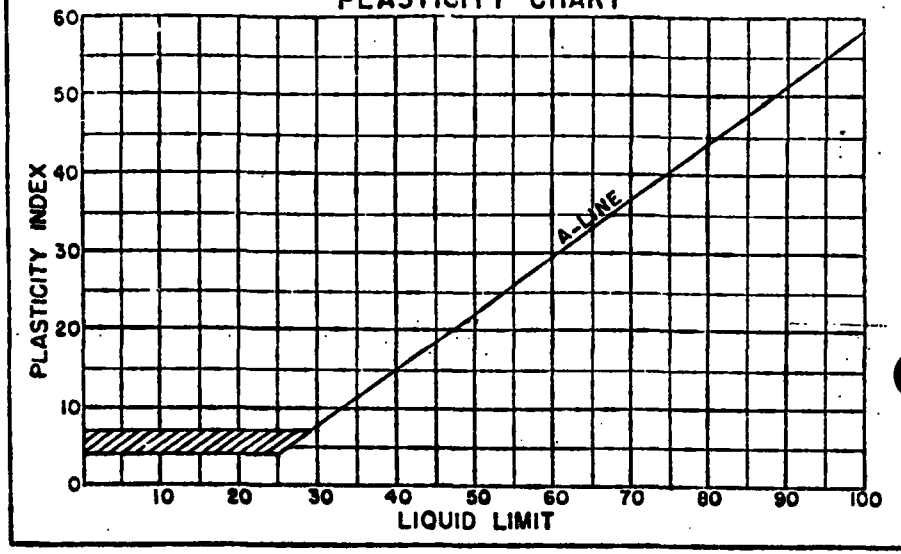
SAMPLE NO. 5881-6 JOB NO. 3037 HOLE NO. 1
DATE 4-17-85 OPERATOR SD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, wet, V SLTY, F SAND

PLASTICITY CHART

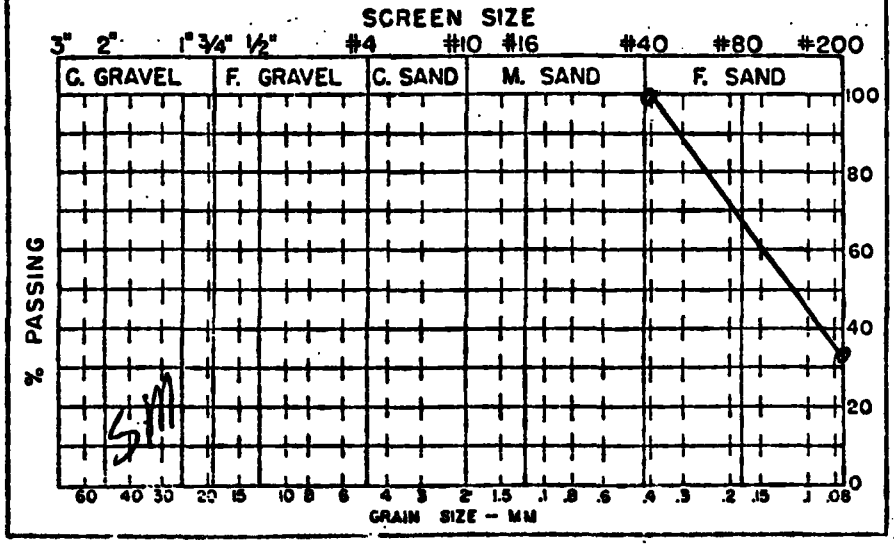


35.2 50.9 43.1

SIEVE ANALYSIS % Passing 58.5

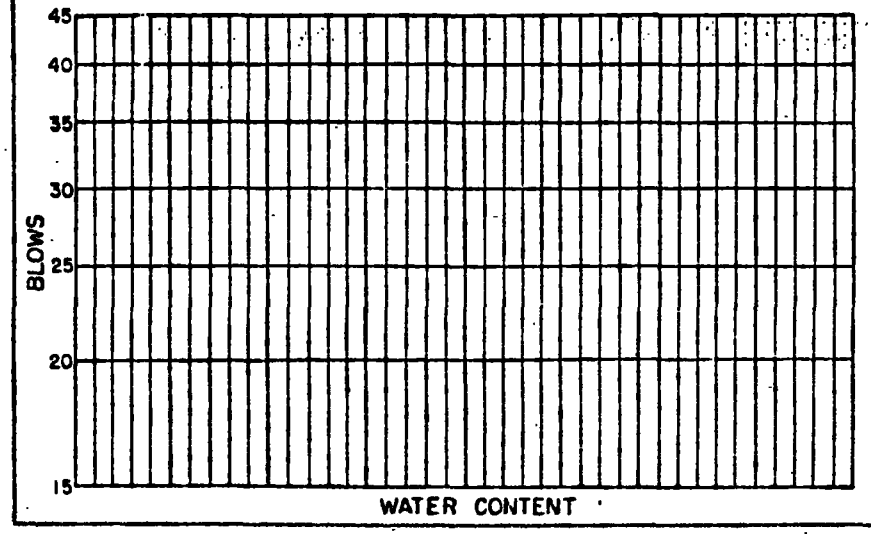
	-40	40.3	100
-3/4	-80		
-4	-140		
-10	-200	18.2	31.1

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



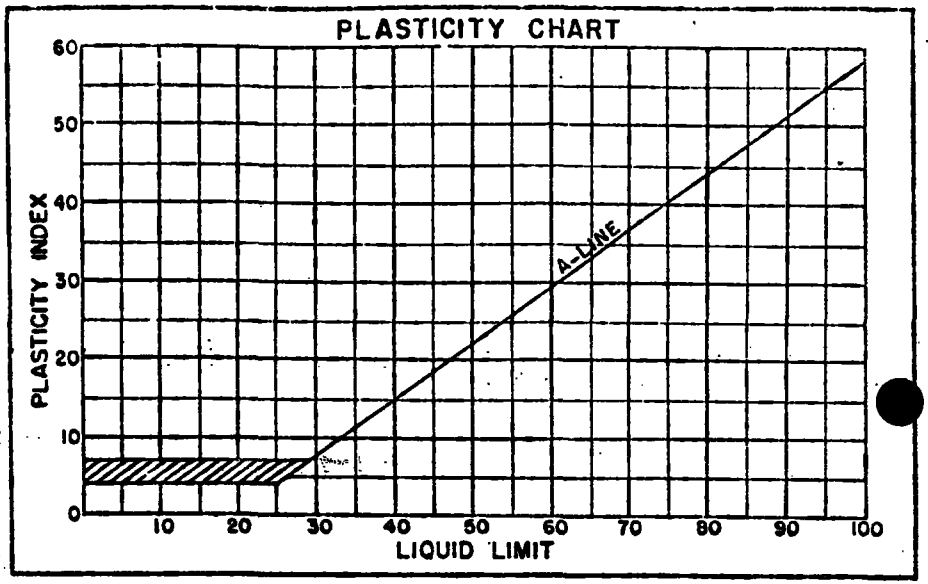
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. SB81-7 JOB NO. C2637 HOLE NO. 1
DATE 4-17-85 OPERATOR [illegible]

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, SLTY, C-F Gravelly C-M-F SAND

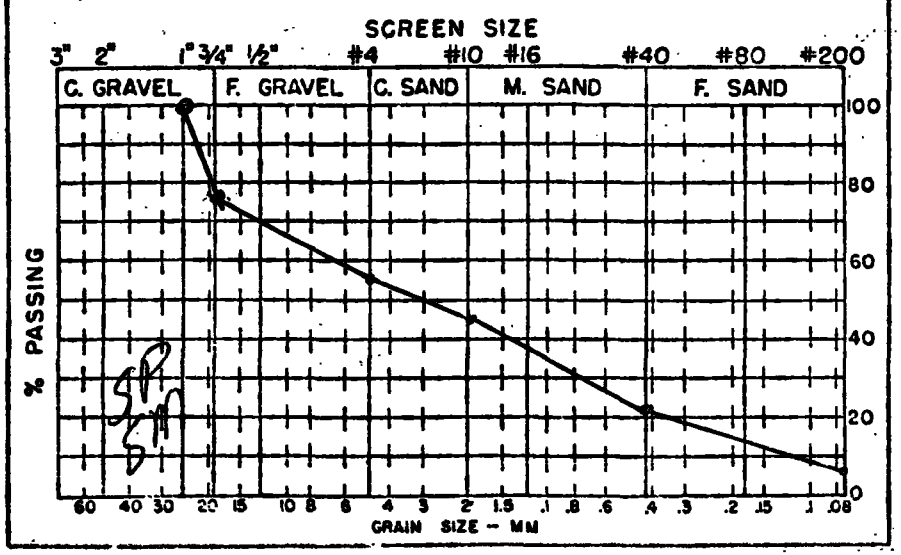


35.8 39.4 10.1

SIEVE ANALYSIS % Passing 145.6

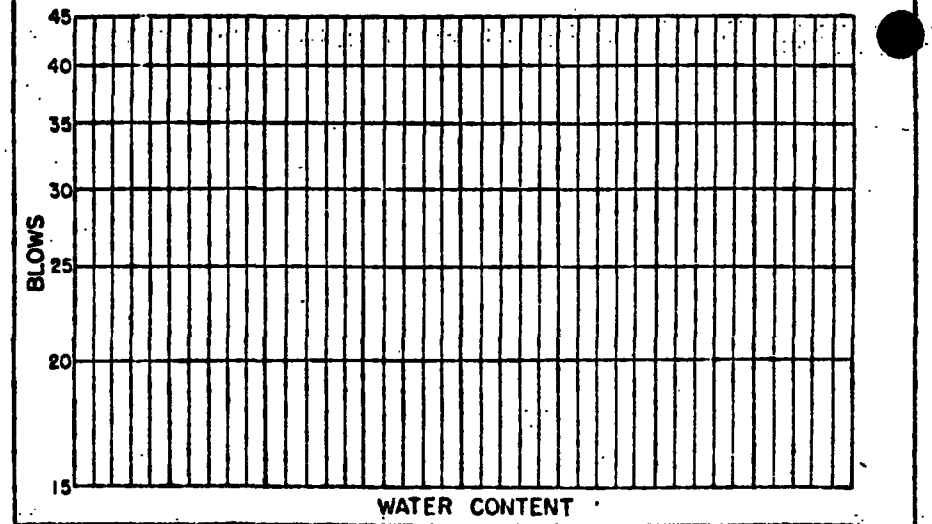
-1 33.75	100	-40	19.65	21.6
-3/4 29.0	76.7	-80		
-4 15.55	56.8	-140		
-10 35.8	46.2	-200	11.85	8.1

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

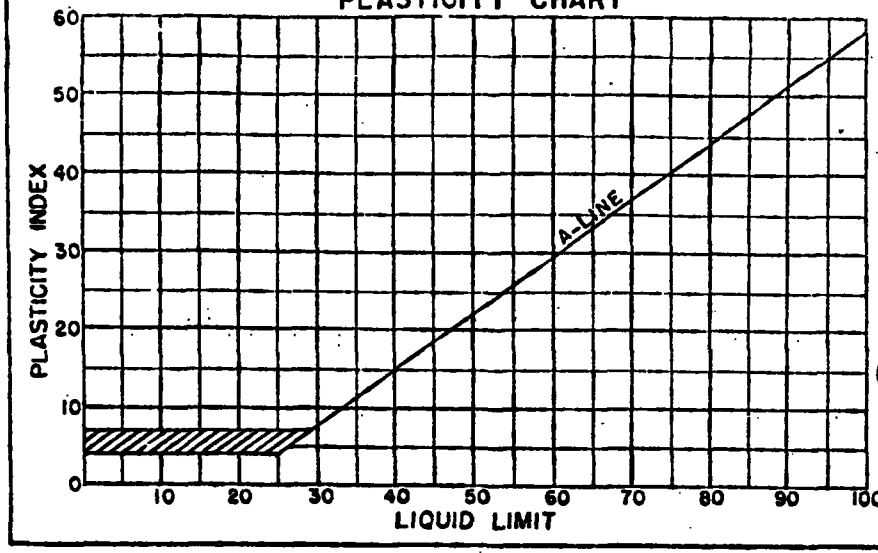
SAMPLE NO. 5881-8 JOB NO. C2637 HOLE NO. 1
DATE 4-17-85 OPERATOR [illegible]

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Bn, Moist, SLTY, C-F Gravelly, C-M-F SAND

PLASTICITY CHART

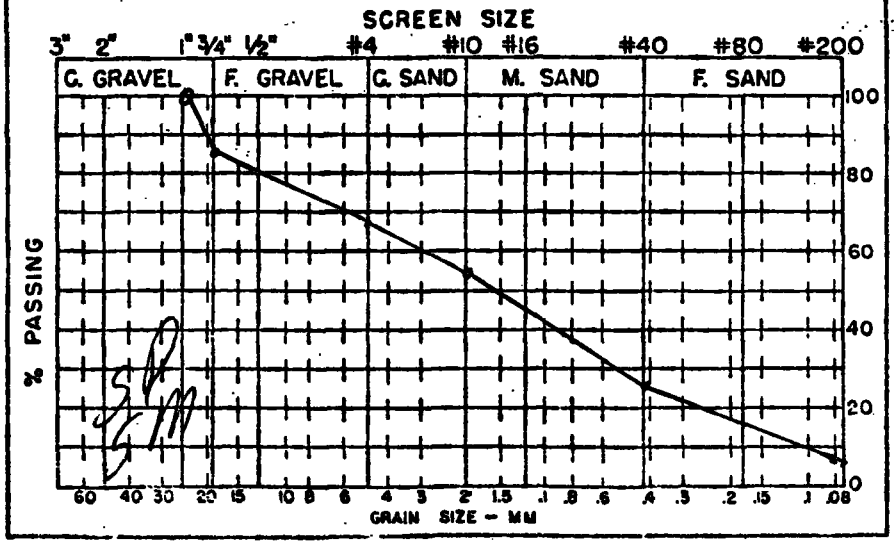


55.5 69.0 24.3

SIEVE ANALYSIS % Passing 161.4

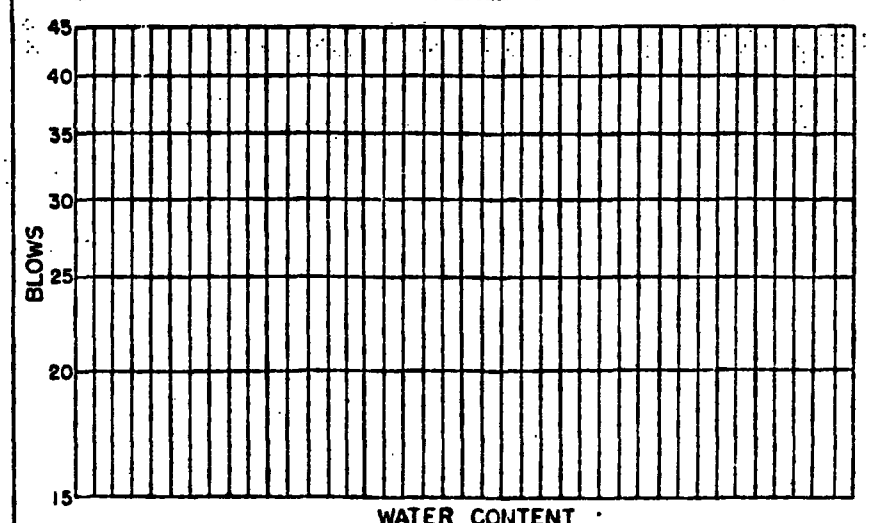
-121.9		100	-40	25.7	24.4
-3/4	28.0	86.2	-80		
-4	24.35	68.9	-140		
-10	47.65	53.9	-200	13.8	8.5

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



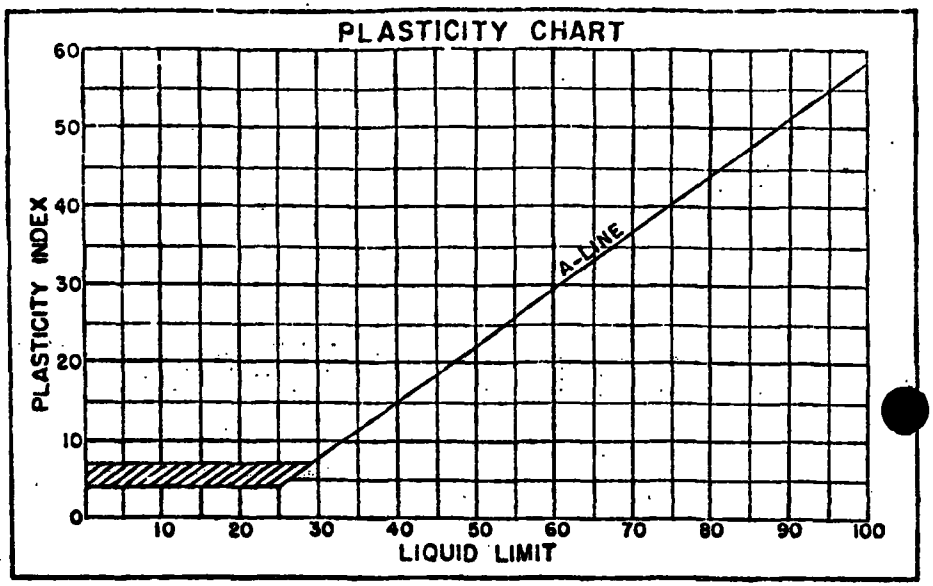
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. SB#10 JOB NO. C2637 HOLE NO. 1
DATE 4-17-85 OPERATOR JD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, Dry, SLTY, C-F Gravelly, C-M-F SAND

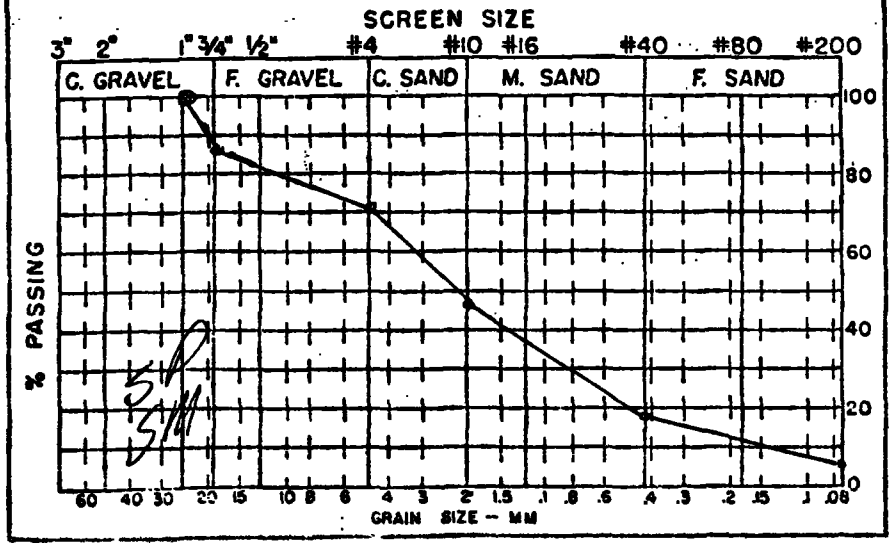


44.75 49.2 9.9

SIEVE ANALYSIS % Passing 56.2

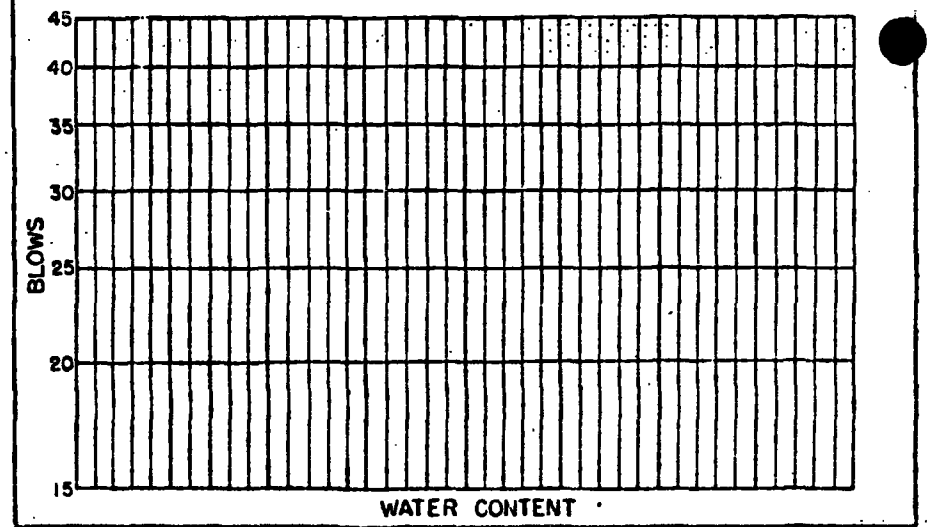
-1	21.1	100	-40 21.0	19.7
-¾	25.5	86.4	-80	
-4	33.2	70.1	-140	
-10	45.5	48.8	-200 9.9	6.3

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Seattle

Date February 25,1985

Dear Sir:

DISTURBED

I have forwarded by today's Hand Carried the following Foundation Samples.

Contract or Job No. C-2637 Section Sunset Blvd. to Factoria I/C SR No. 405 Sub-Section

Station & Offset 376+35 115'LT ℄ Hole # 2

E Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
5990-1	P-1	-1.0' to -3.0'	H2O = 16.7	SM	
-2	P-2	-3.0' to -5.0'	H2O = 9.7	SM	
-3	P-3	-5.0' to -7.0'	H2O = 12.4	SM	
-4	P-4	-7.5' to -9.5'	H2O = 11.7	SM	
-5	P-5	-10.0' to -12.0'	H2O = 11.1	SM	
-6	P-7	-15.0' to -17.0'	H2O = 19.3	SM	
-7	P-8	-17.5' to -19.5'	H2O = 34.3	SM	
-8	P-9	-20.0' to -22.0'	H2O = 20.2	SM	
-9	P-10	-22.5' to -24.5'	H2O = 17.4	SM	

1 copy with samples
1 copy to addressee

Yours very truly,

KEW (RMM)

Inspector.

DOT FORM 351-002 REVISED 2/80

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Seattle

Date February 25, 1985

Dear Sir:

I have forwarded by today's Hand Carried the following DISTURBED Foundation Samples.

Contract or Job No. C-2637 Section Sunset Blvd. to Factoria I/C SR No. 405 Sub-Section

Station & Offset 376+35 115'LT ℄ Hole # 2

E Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
5990-10	P-11	-25.0' to -27.0'	H2O= 26.2	SM	
-11	P-12	-27.5' to -30.0'	H2O= 28.8	ML	
-12	P-13	-30.0' to -32.0'	H2O= 29.0	ML	
-13	P-14	2.5' to -34.5'	H2O= 27.3	SM	
-14	P-15	-35.0' to -37.0'	H2O= 21.2	SM	
-15	P-16	-37.5' to -39.5'	H2O= 10.6	SP SM	

1 copy with samples
1 copy to addressee

Yours very truly,

KEW (RMM)

Inspector.

DOT FORM 351-002 REVISED 2/80

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

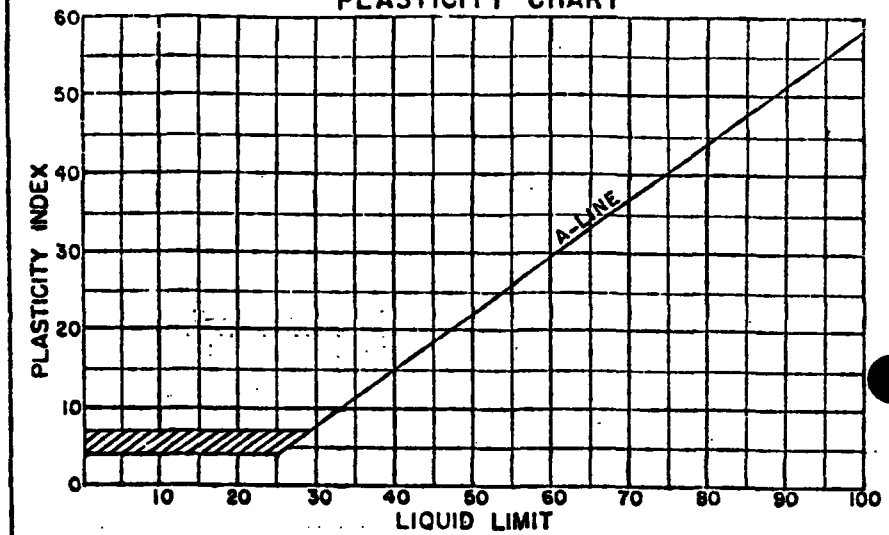
SAMPLE NO. 5880-1 JOB NO. C2637 HOLE NO. 2
DATE 4-17-85 OPERATOR JD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Br, moist, SLTY, C-F Gravelly, C-M-F SAND

PLASTICITY CHART

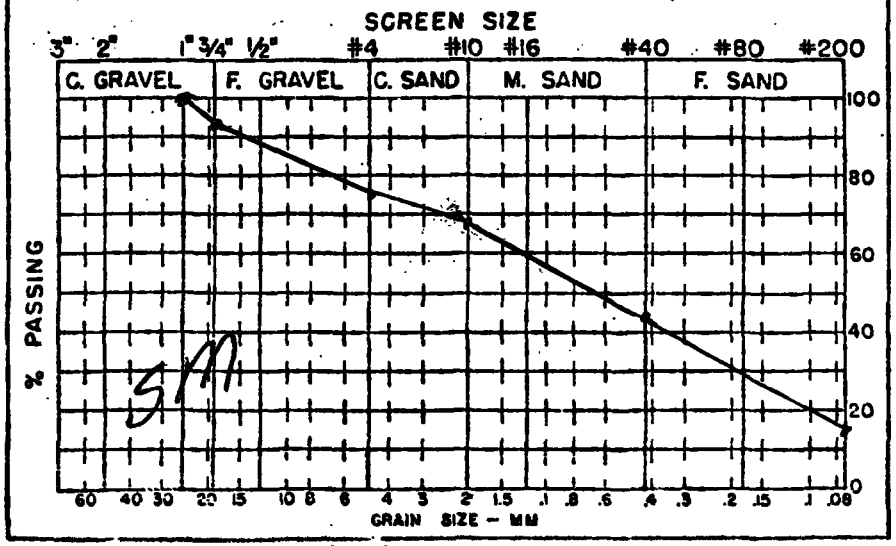


39.15 45.7 16.7

SIEVE ANALYSIS % Passing 234.7

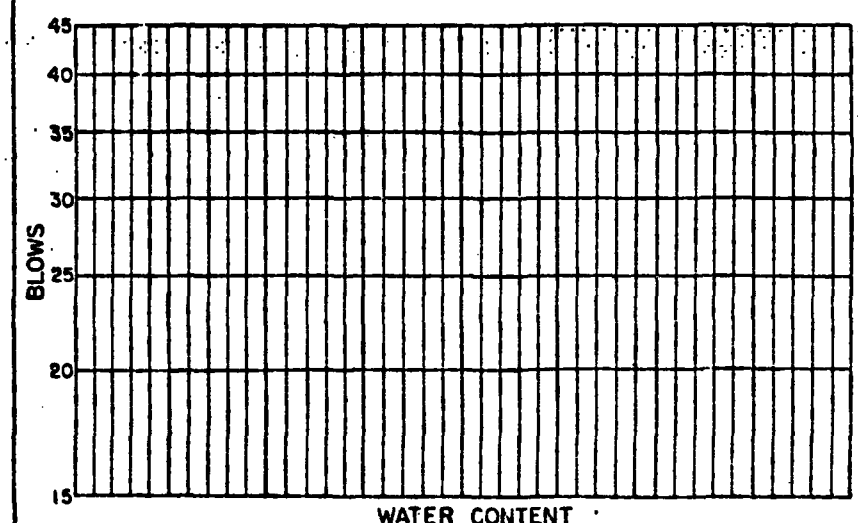
-1	18.0	100	-40	66.35	43.7
-3/4	35.75	92.4	-80		
-4	17.05	77.2	-140		
-10	61.55	69.9	-200	36.0	15.4

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5880-2 JOB NO. C2637 HOLE NO. 2

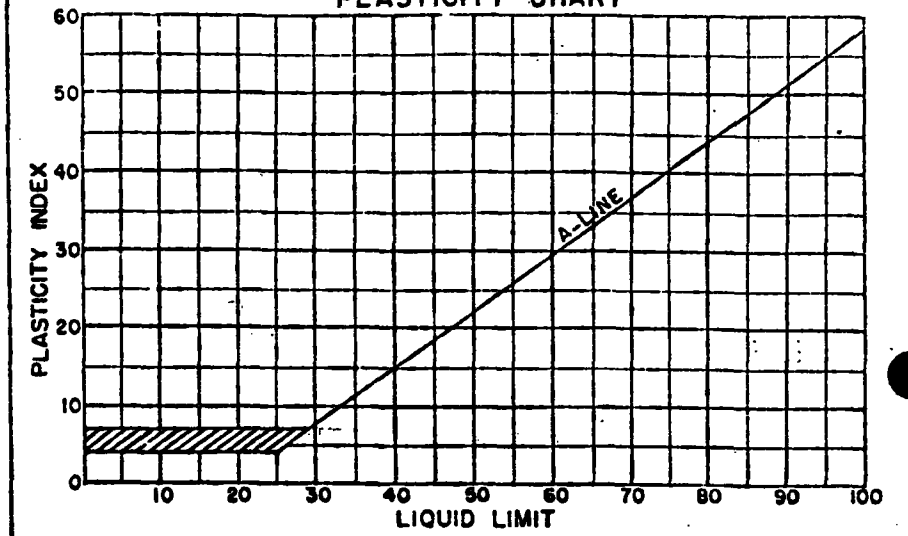
DATE 4-17-85 OPERATOR LO

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, Dry, F Gravelly, V Slty, C, m-F SAND

PLASTICITY CHART

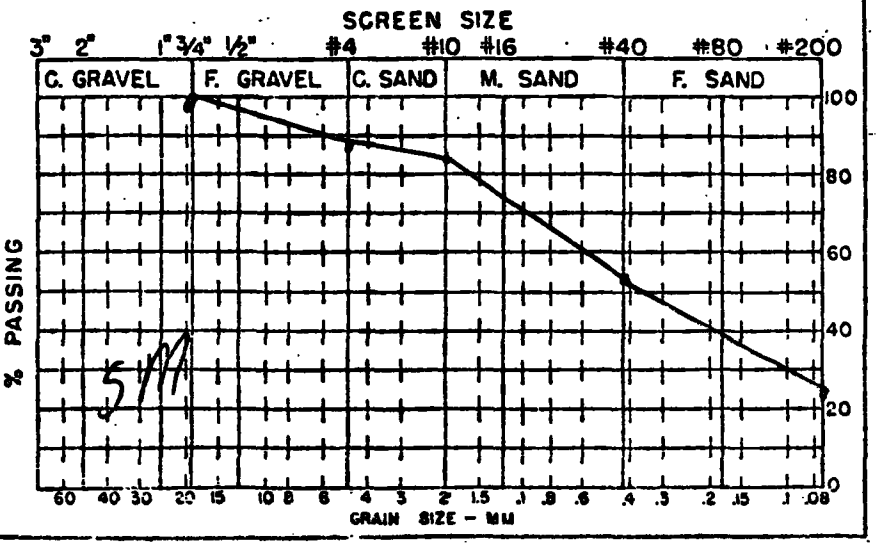


53.05 58.2 9.1

SIEVE ANALYSIS % Passing 241.85

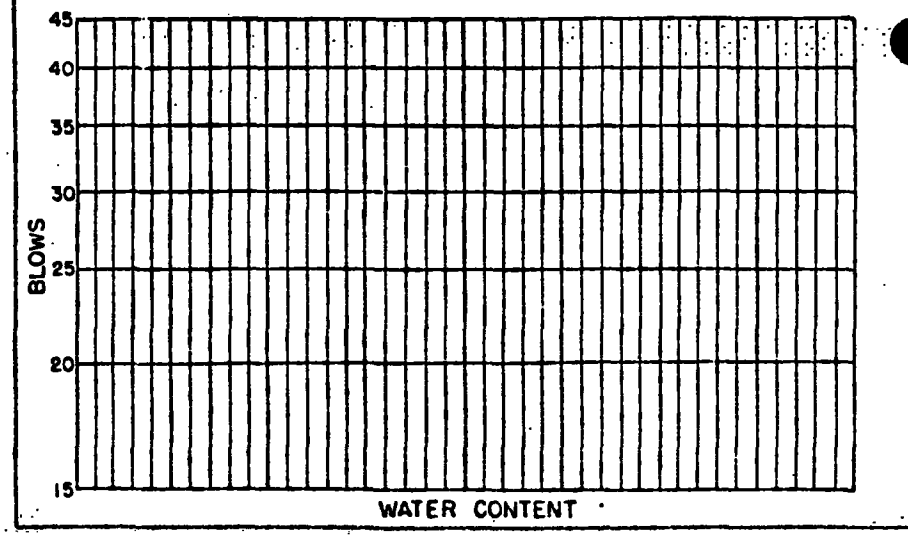
		-40	22.75	53.7
-¾	25.1	100	-80	
-4	8.0	89.4	-140	
-10	11.5	85.7	-200 57.5	23.7

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

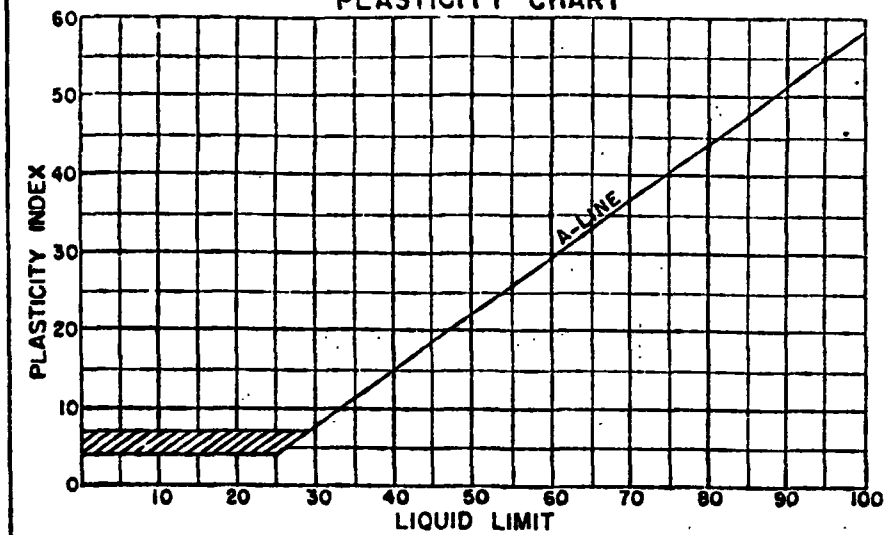
SAMPLE NO. 5880-3 JOB NO. C2637 HOLE NO. 2
DATE 4-17-85 OPERATOR JD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, F Gravelly, SLTY, C-M-F SAND

PLASTICITY CHART

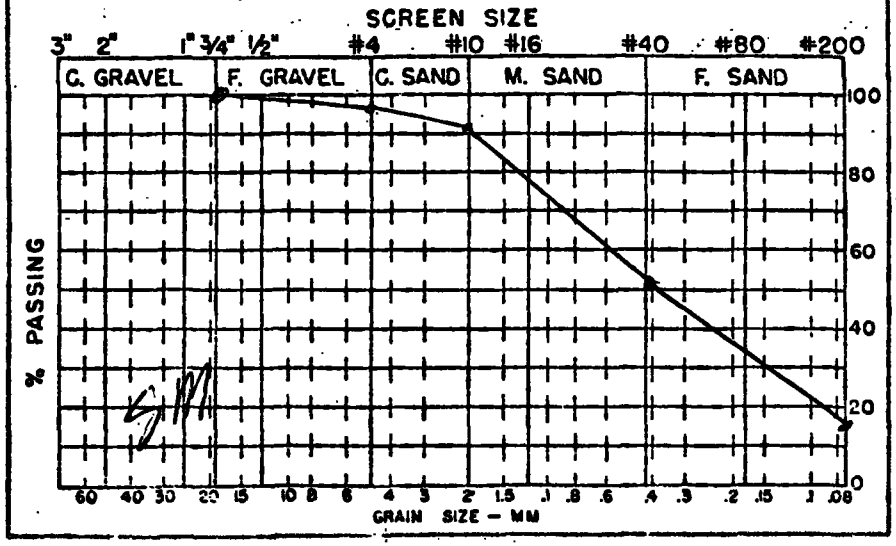


54.0 60.7 12.4

SIEVE ANALYSIS % Passing 250.9

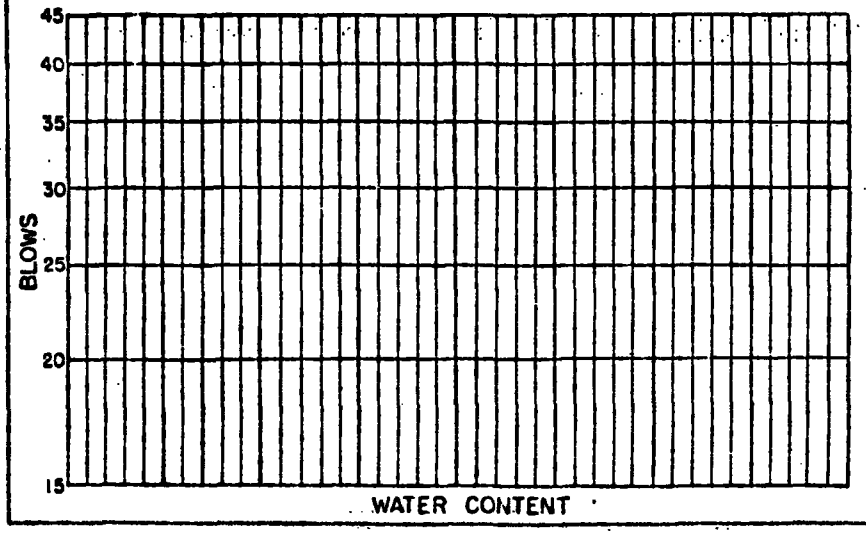
			-40	88.25	50.4
-3/4	5.15	100	-80		
-4	17.2	97.9	-140		
-10	102.0	91.05	-200	38.3	15.2

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



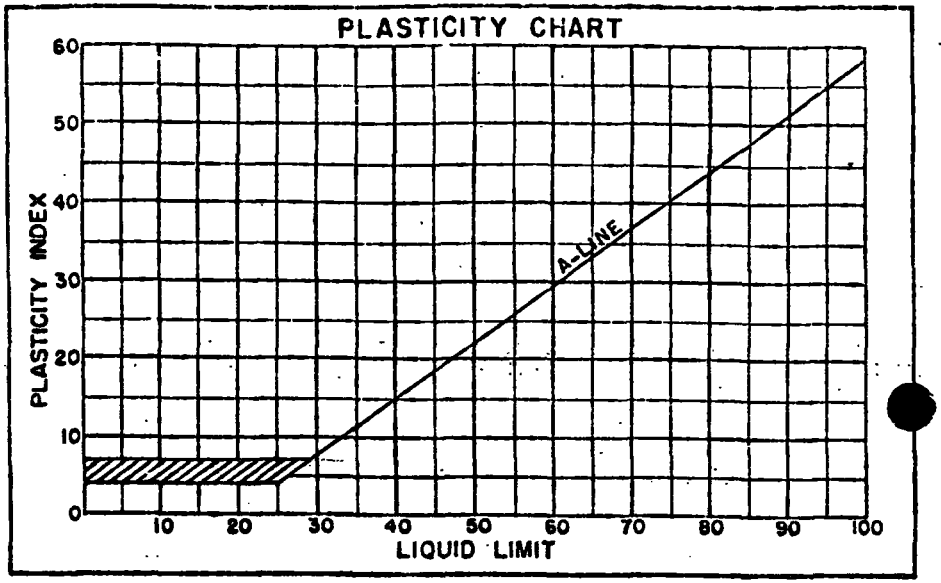
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 58854 JOB NO. C2637 HOLE NO. 2
DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, F Gravelly SILTY, C-M-F SAND

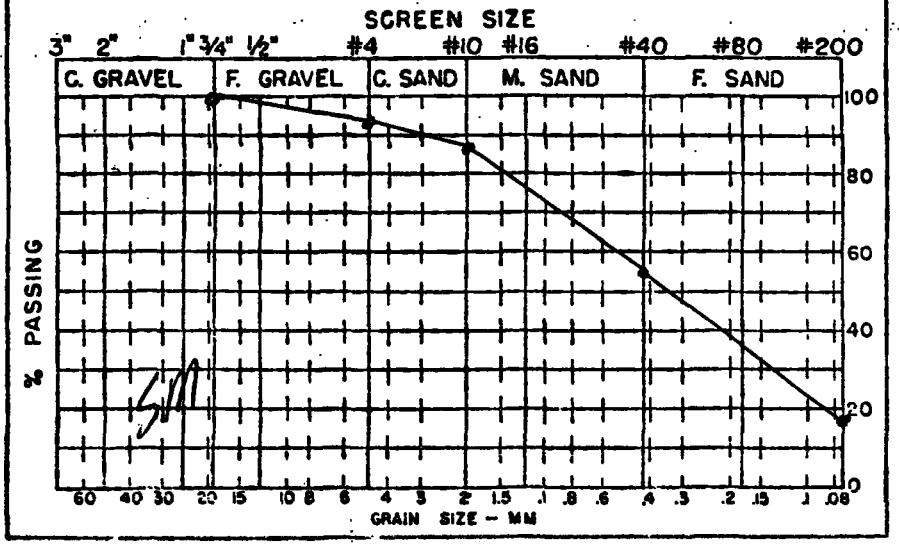


63.1 20.5 11.7

SIEVE ANALYSIS % Passing 231.0

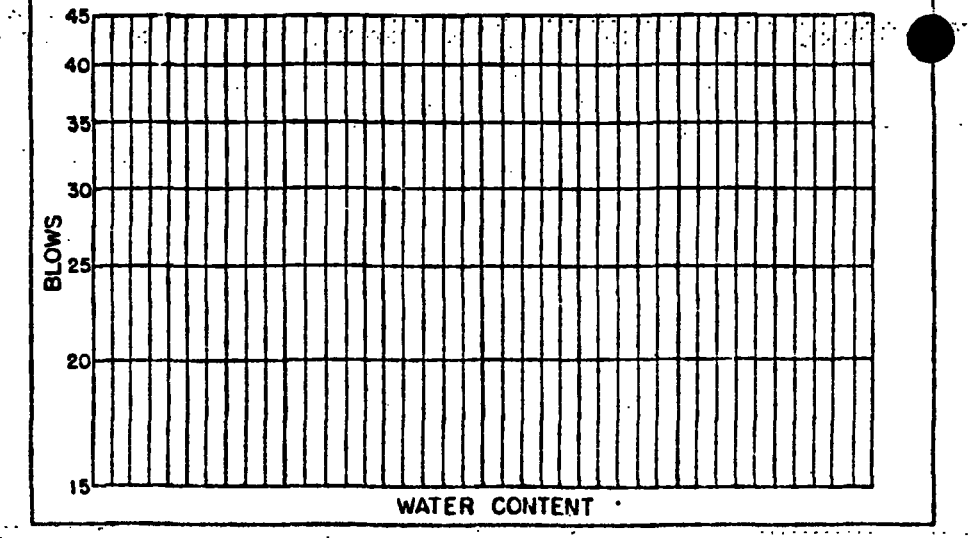
		-40	85.6	55.3
-¾	16.0	100	-80	
-4	10.8	93.2	-140	
-10	76.3	88.3	-200 42.3	18.3

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5888-5 JOB NO. C2637 HOLE NO. 2

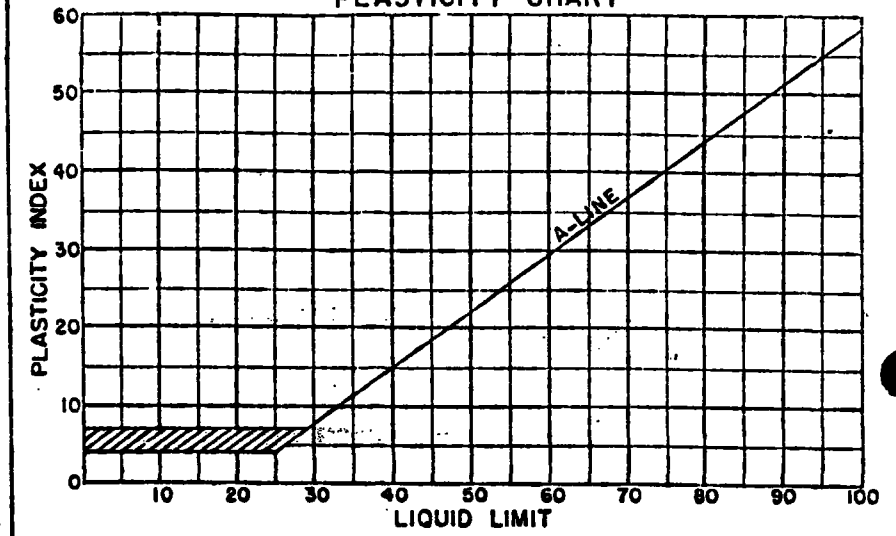
DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, F Gravelly Silty, C-M-F SANDS

PLASTICITY CHART

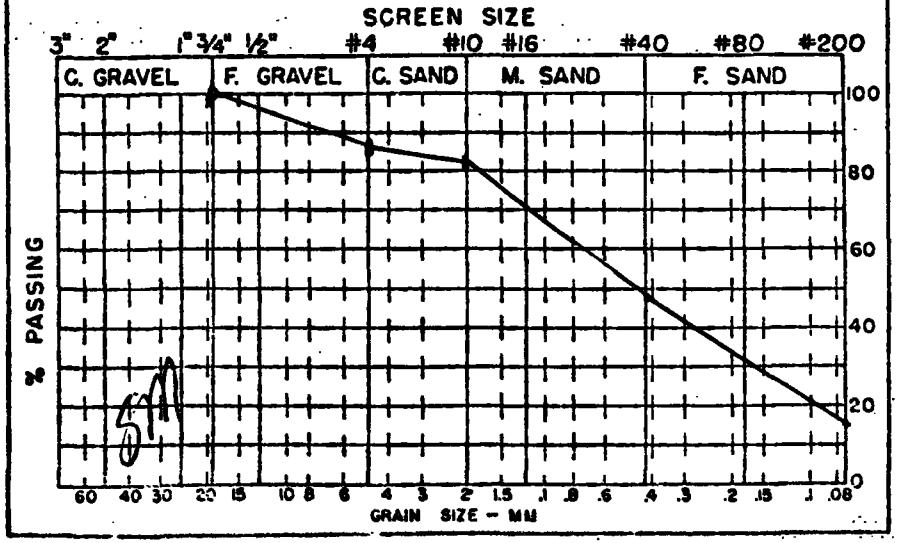


48.35 537 1111

SIEVE ANALYSIS % Passing 146.9

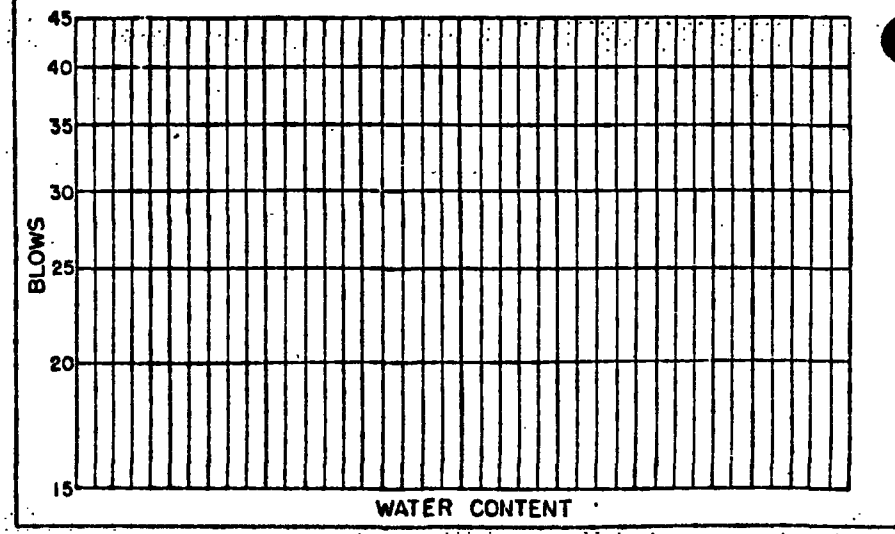
		-40	49.5	49.6
-¾	17.0	-80		
-4	2.7	-140		
-10	49.25	-200	23.4	15.9

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

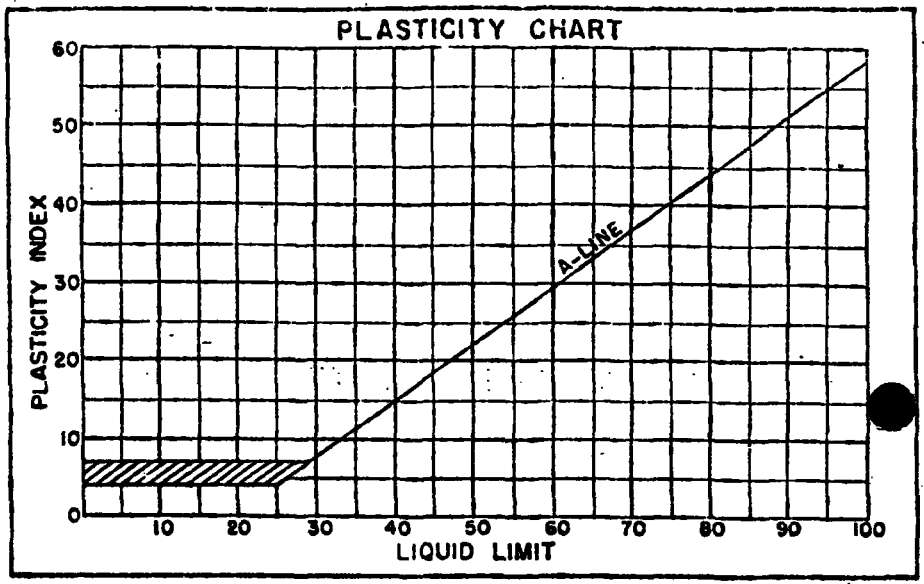
SAMPLE NO. 3880-6 JOB NO. 2637 HOLE NO. 2

DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, F Gravelly V SLTY, C-M-F SAND

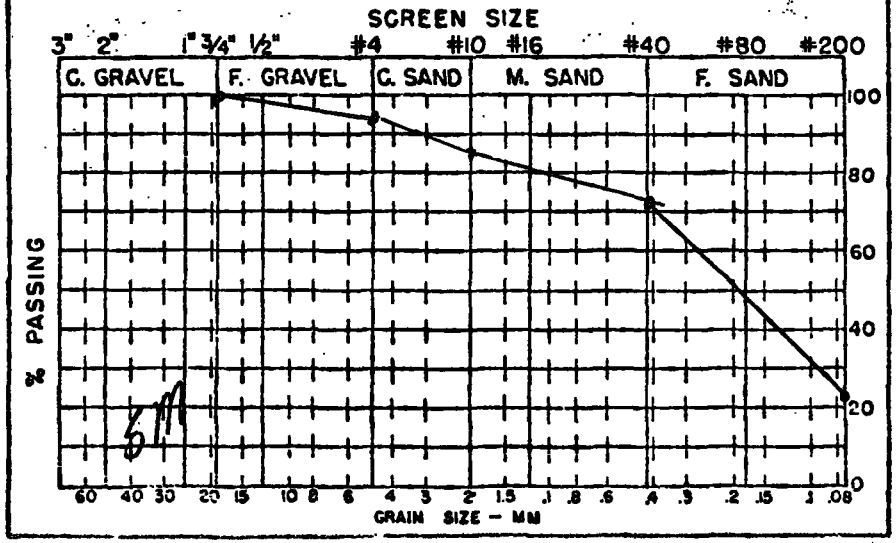


81.55 97.3 19.3

SIEVE ANALYSIS % Passing #200

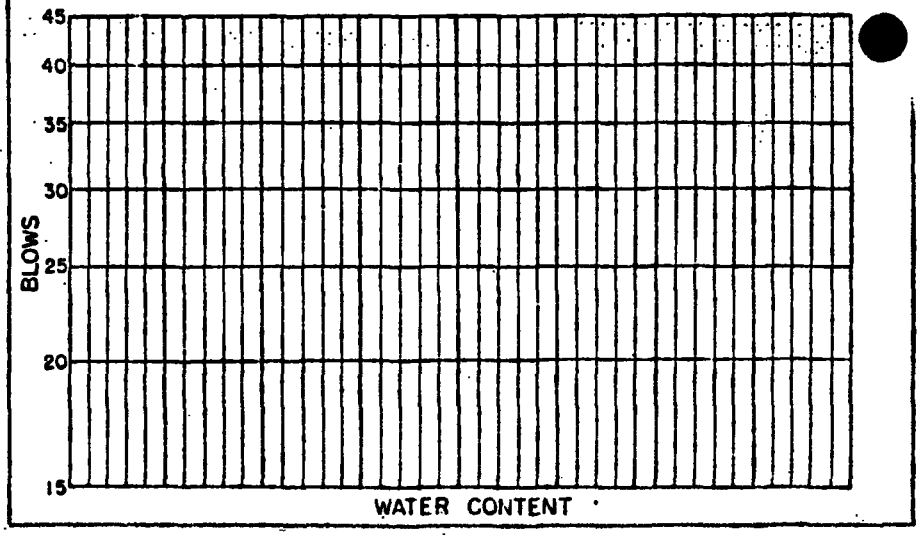
		-40	94.2	71.2
-3/8	1.38	100	-80	
-4	15.5	92.5	-140	
-10	25.2	84.4	-200 49.4	21.7

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



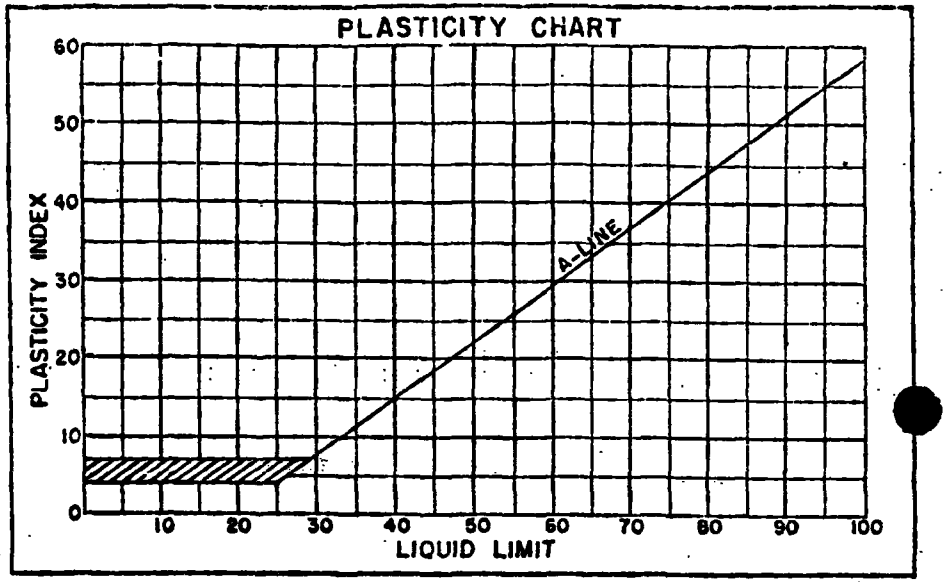
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. SB80-7 JOB NO. 2637 HOLE NO. 2
DATE 1-17-85 OPERATOR LD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, Wet, F Gravelly, V SLTY, C-M-F SAND

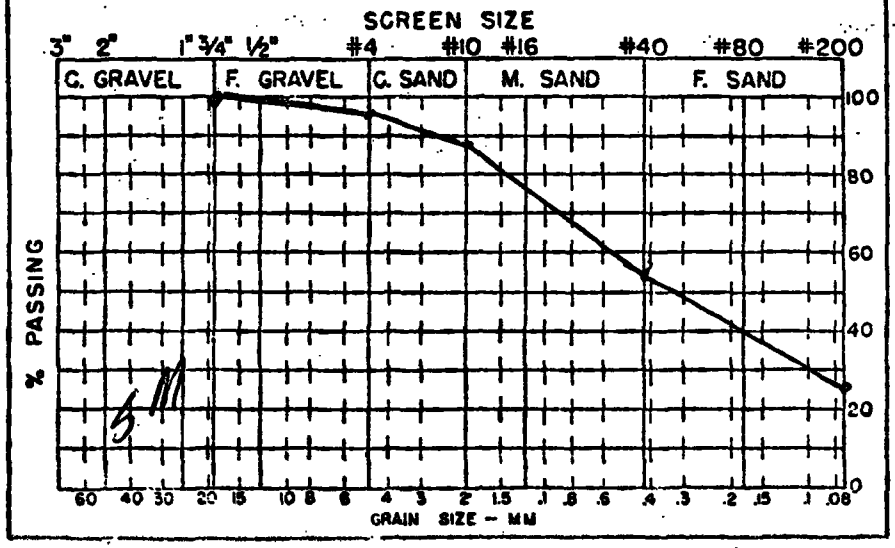


39.1 32.1 34.3

SIEVE ANALYSIS % Passing 164.5

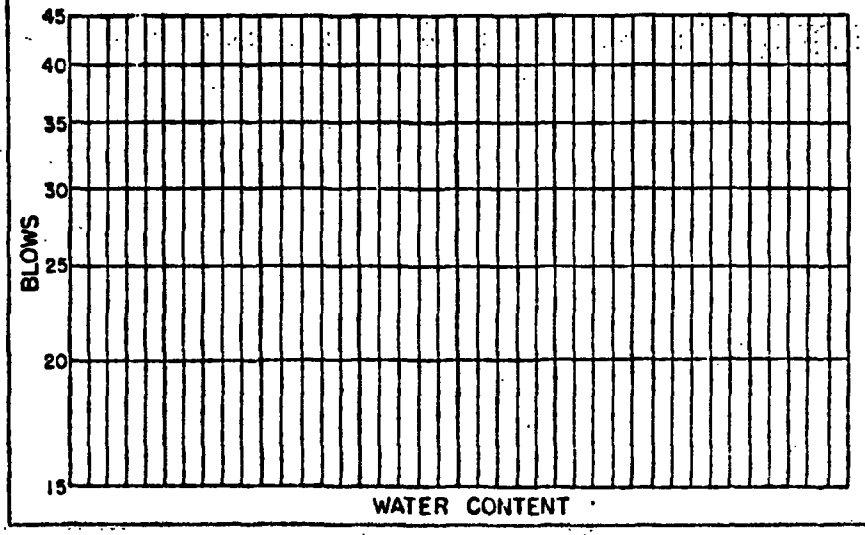
		-40	47.5	54.1
-¾ 5.2	100	-80		
-4 116.5	96.8	-140		
-10 58.75	89.8	-200	41.4	25.2

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 8880-8 JOB NO. 82637 HOLE NO. 2

DATE 4-16-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

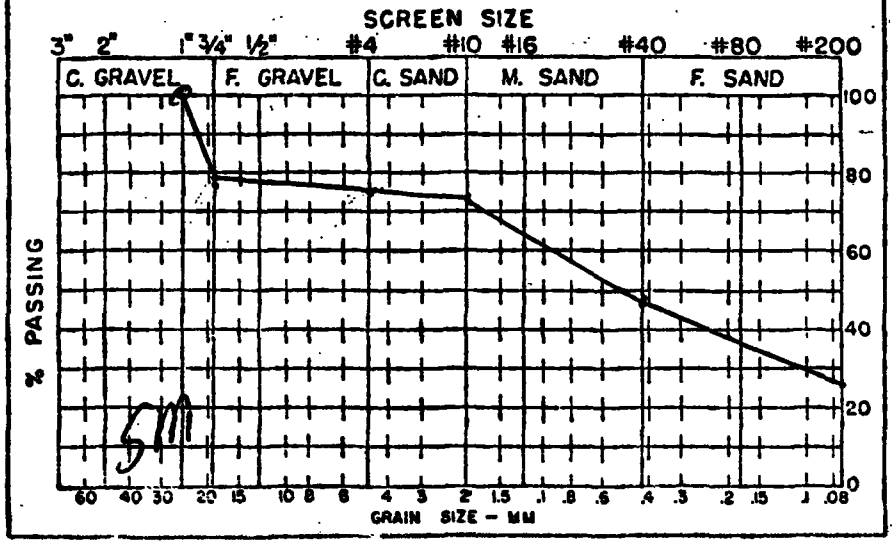
DESCRIPTION: Brn, moist, V SLTY, C-F Gravelly, C-M-F SAND

58.5 70.3 20.2

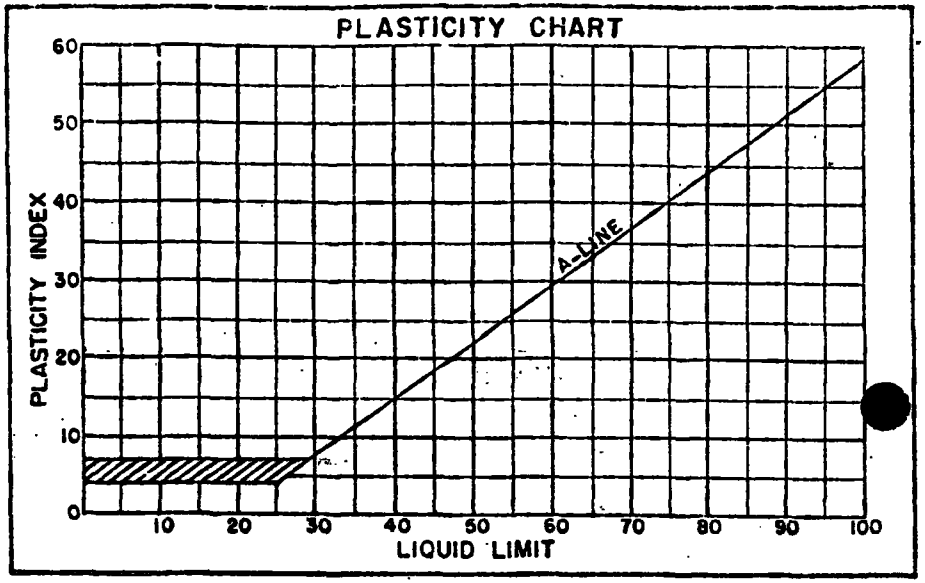
SIEVE ANALYSIS % Passing 2/9/2

-1	48.3	100	-40	48.4 48.9
-3/4	3.75	77.8	-80	
-4	6.5	76.1	-140	
-10	53.2	73.1	-200	59.05 26.9

GRAIN SIZE CURVE

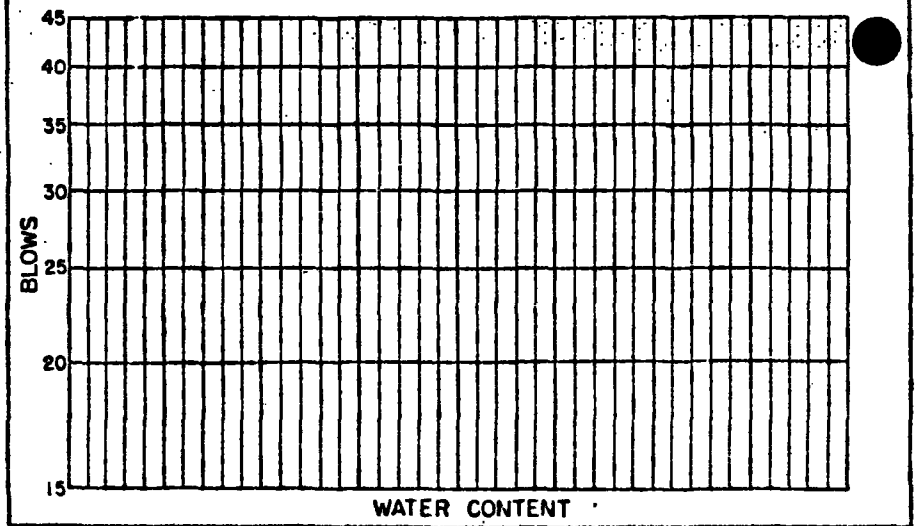


PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



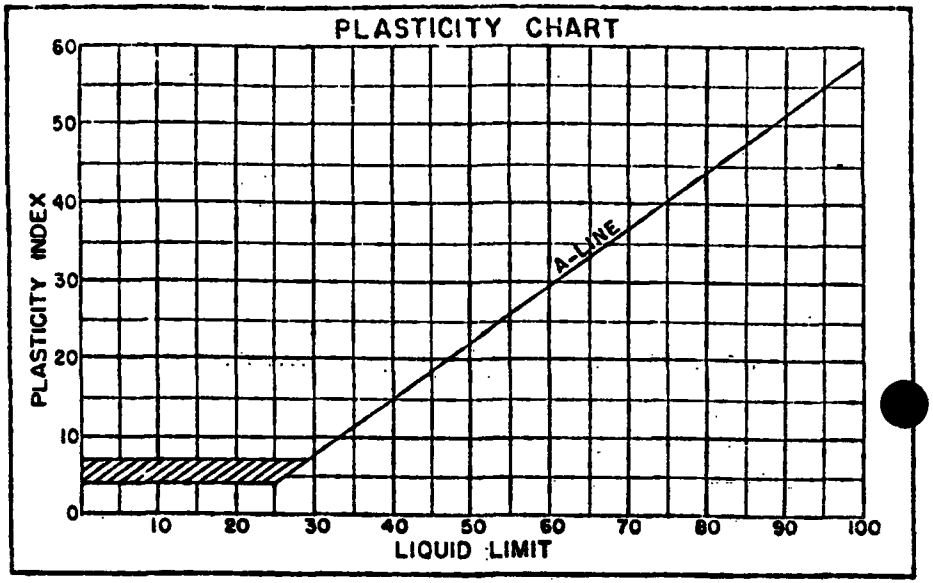
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. SB80-9 JOB NO. C2637 HOLE NO. 2
DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, F Gravelly, V SLTY, C-M-F SAND

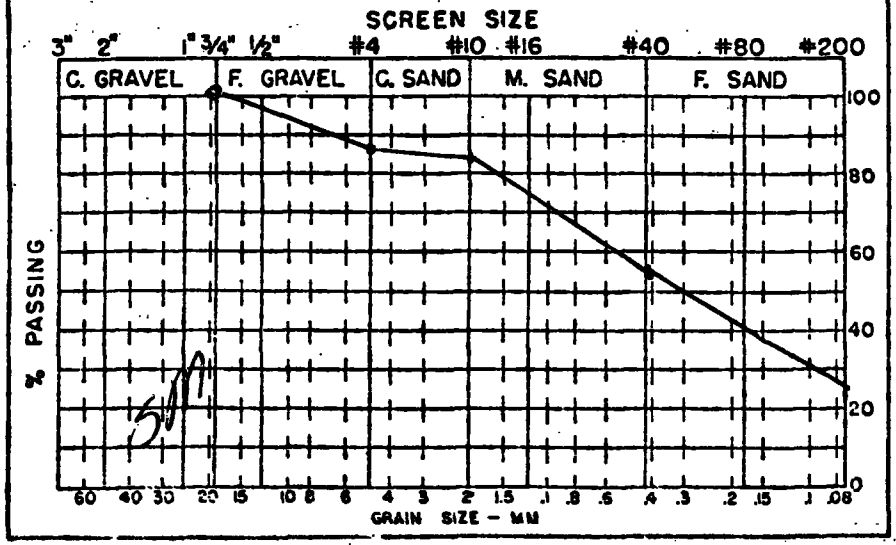


42.4 49.8 17.4

SIEVE ANALYSIS % Passing 214.7

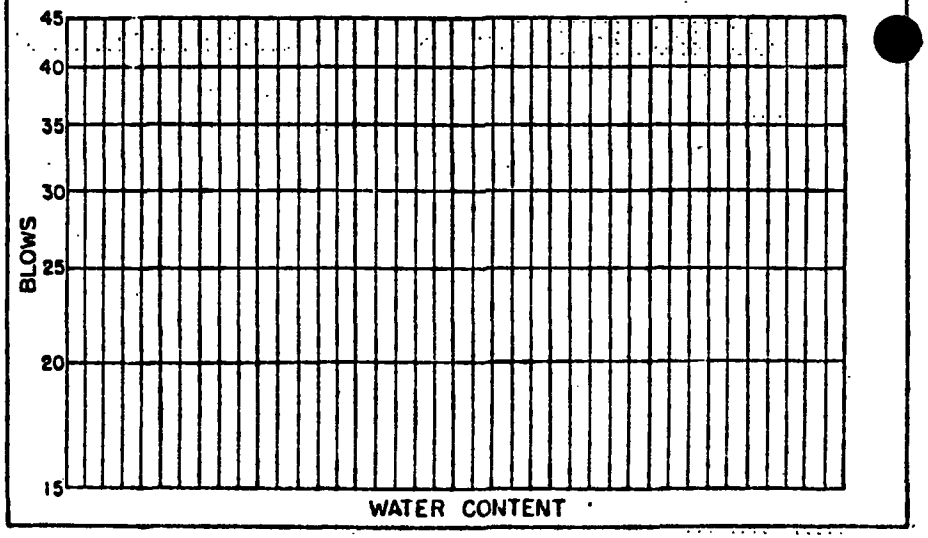
		-40	68.0	55.5
-¾	26.2	100	-80	
-4	12.2	87.5	-140	
-10	56.8	81.9	-200	51.5	23.9

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 558010 JOB NO. C2437 HOLE NO. 2

DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

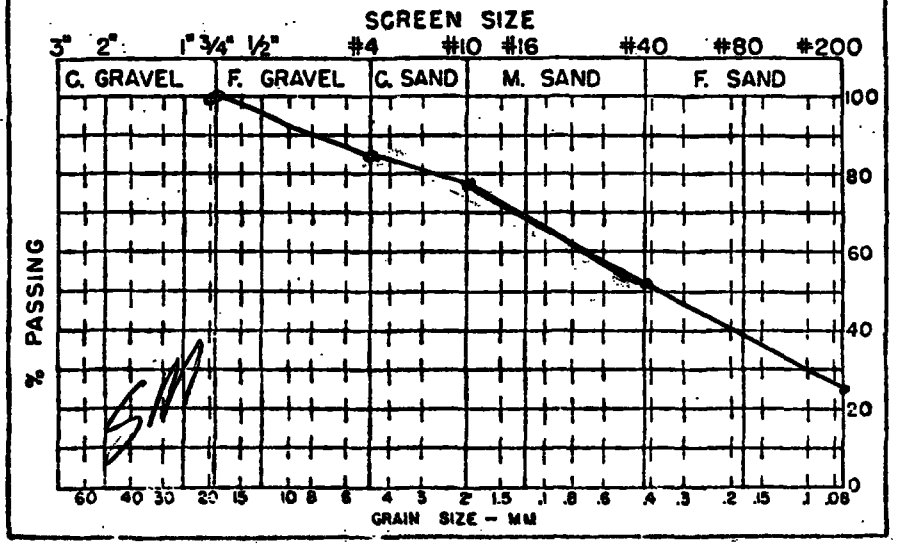
DESCRIPTION: Brn, Moist, F Gravelly, V SLTY, C-M-F SAND

39.9 50.35 26.2

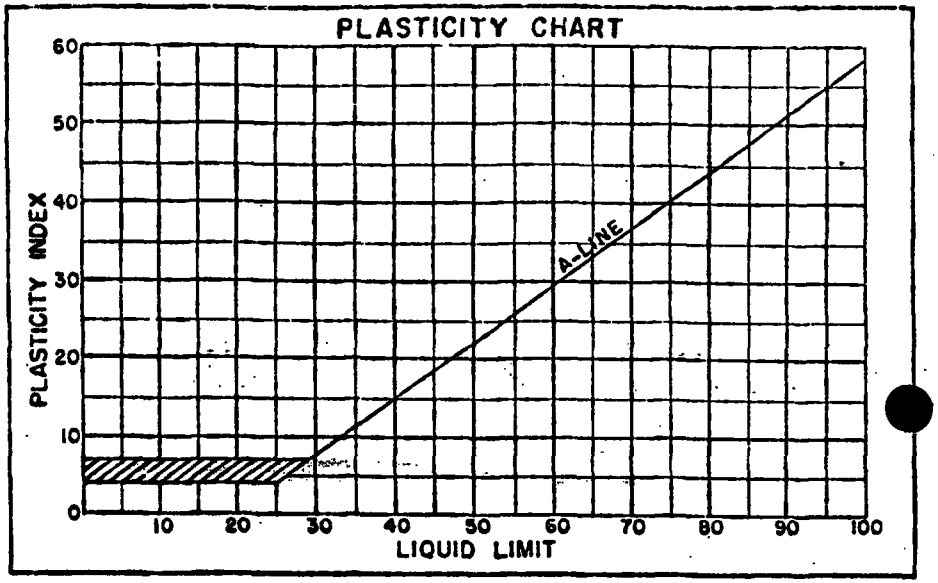
SIEVE ANALYSIS % Passing 225.7

		-40	59.0	51.7
-3/4	35.0	100	-80	
-4	12.85	84.4	-140	
-10	60.9	78.7	-200 57.95	25.6

GRAIN SIZE CURVE

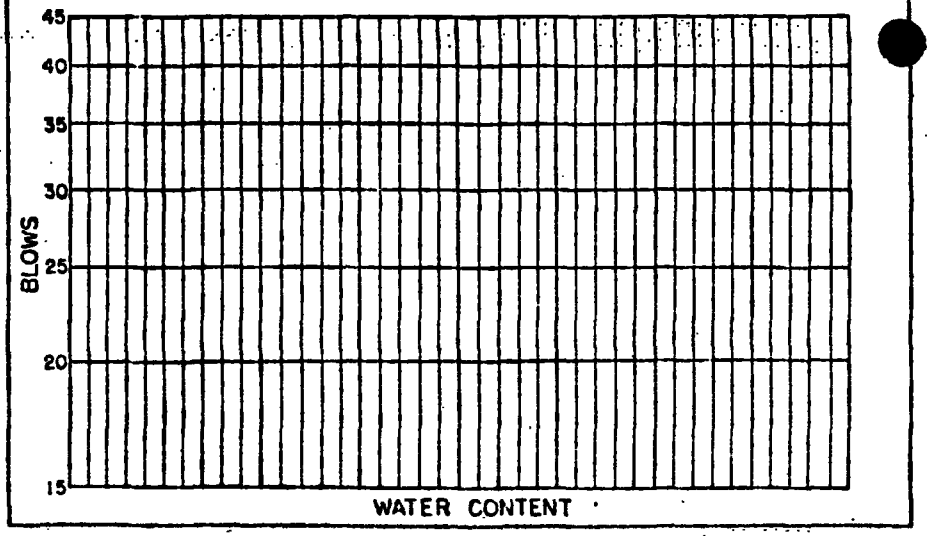


PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

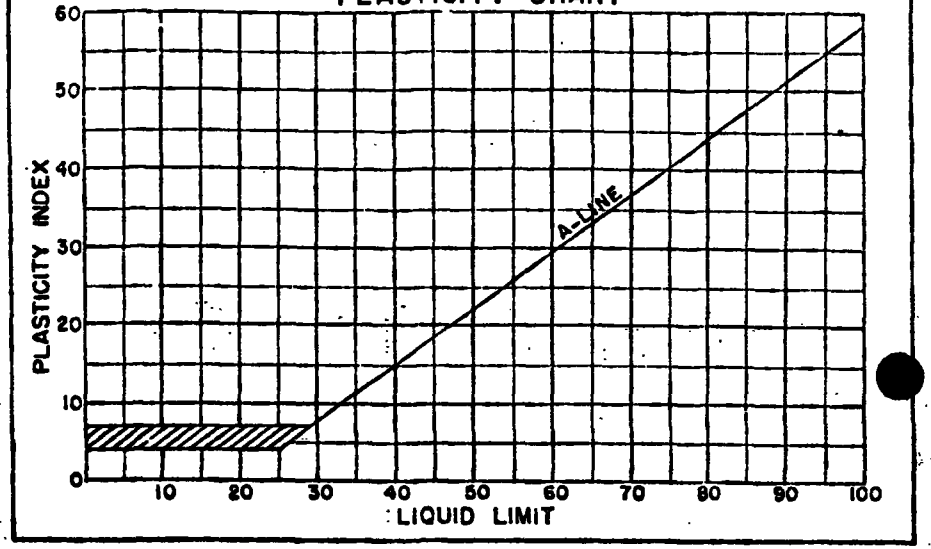
SAMPLE NO. SB8011 JOB NO. C2637 HOLE NO. 2

DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	~	~	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, M-F SAND, SLT

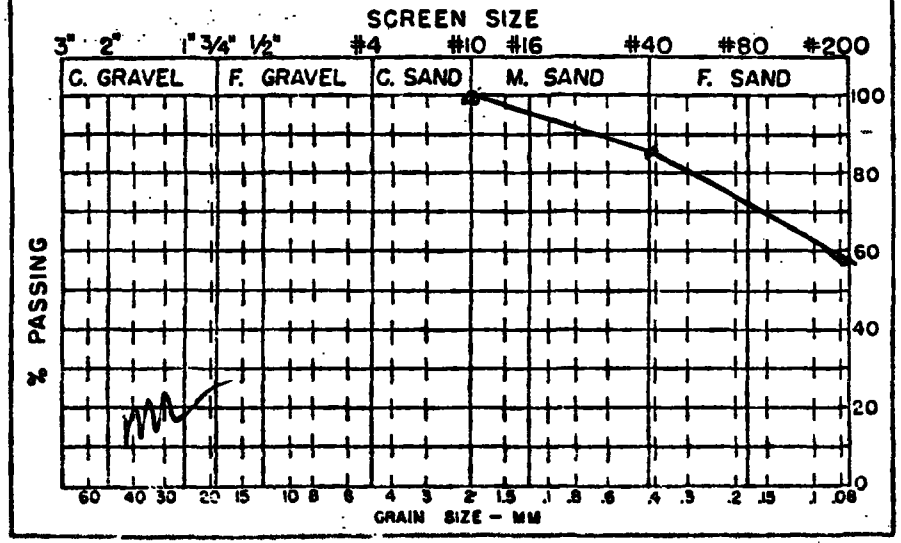


37.8 48.7 28.8

SIEVE ANALYSIS % Passing 135.4

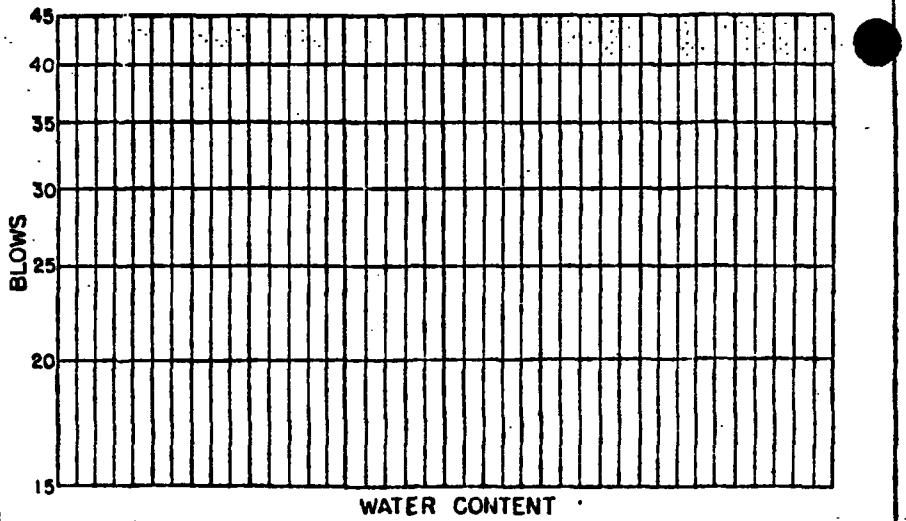
	-40	34.5	84.9
-3/4	-80		
-4	-140		
-10 70.35 100	-200	80.55	59.5

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

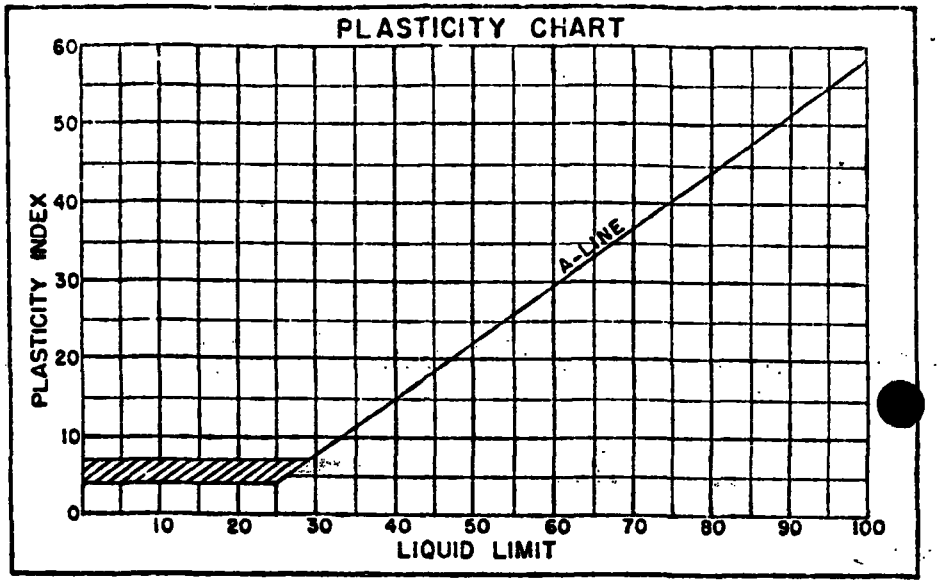
SAMPLE NO. SBB012 JOB NO. 02637 HOLE NO. 2

DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Br, moist, FSANDY, SLT

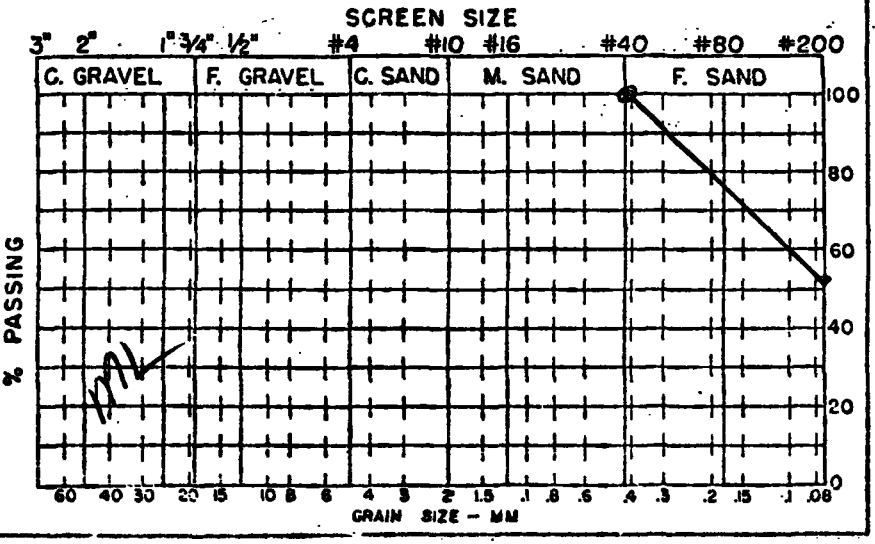


SIEVE ANALYSIS % Passing

	-40	70.4	100
-3/4	-80		
-4	-140		
-10	-200	74.1	51.3

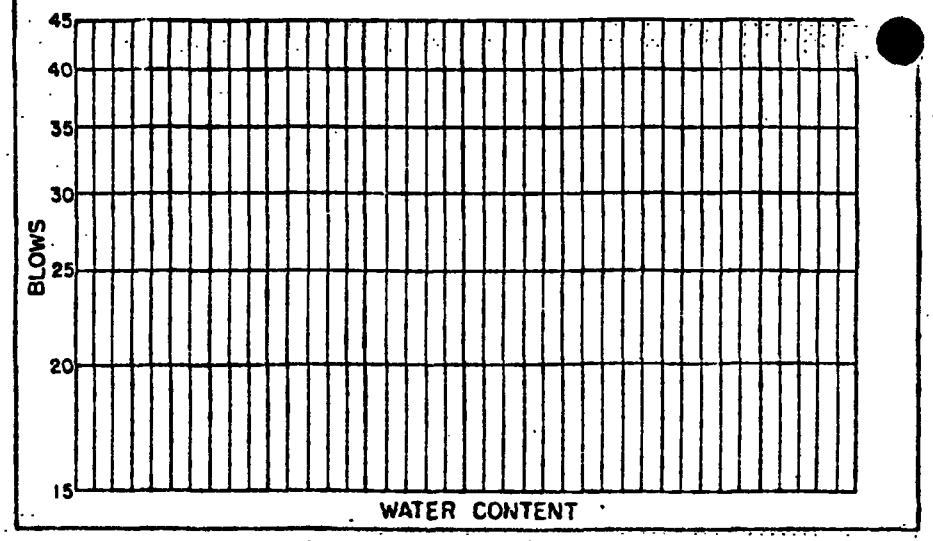
36.6 51.1 29.0 14.5

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5380-13 JOB NO. C2637 HOLE NO. 2
DATE 4-17-85 OPERATOR [illegible]

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

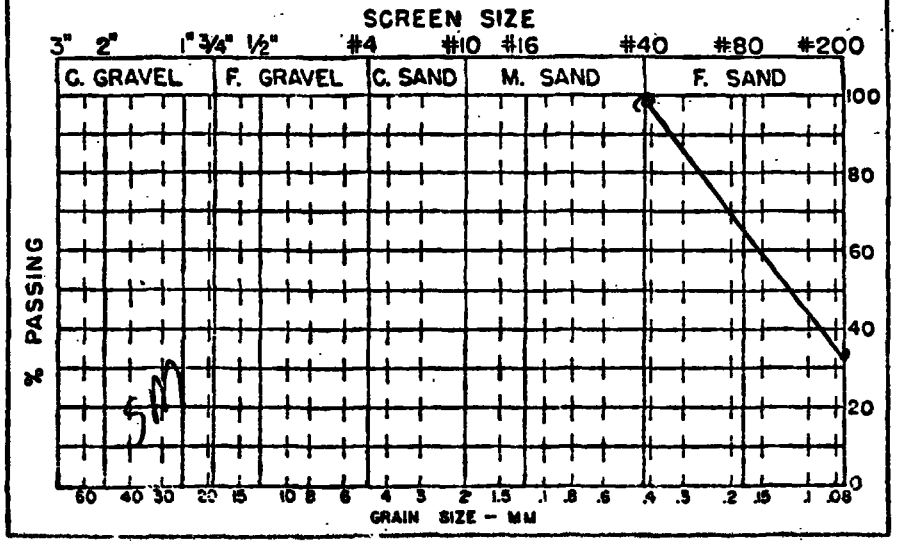
DESCRIPTION: Brn, moist, VSLTY, FSAND

25.6 32.6 27.3

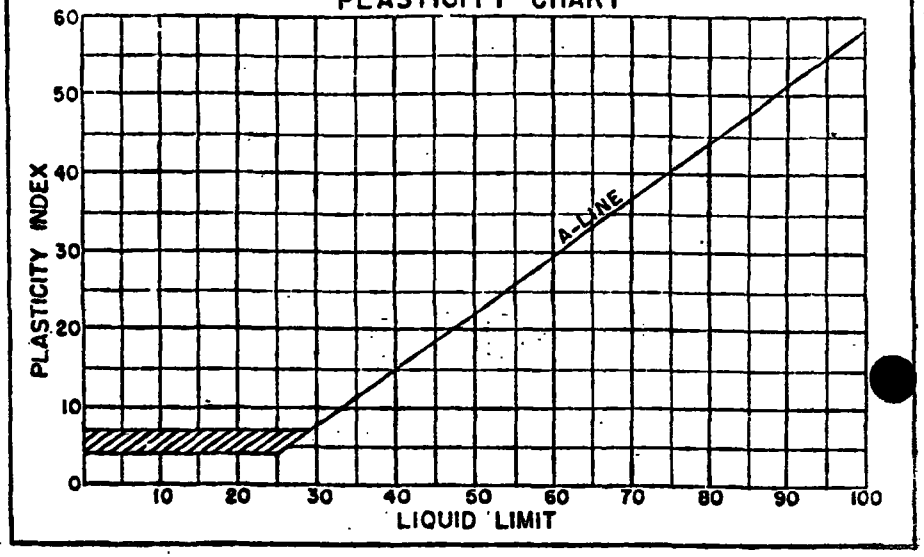
SIEVE ANALYSIS % Passing 1430

	-40	96.5	100
-¾	-80		
-4	-140		
-10	-200	46.5	32.5

GRAIN SIZE CURVE

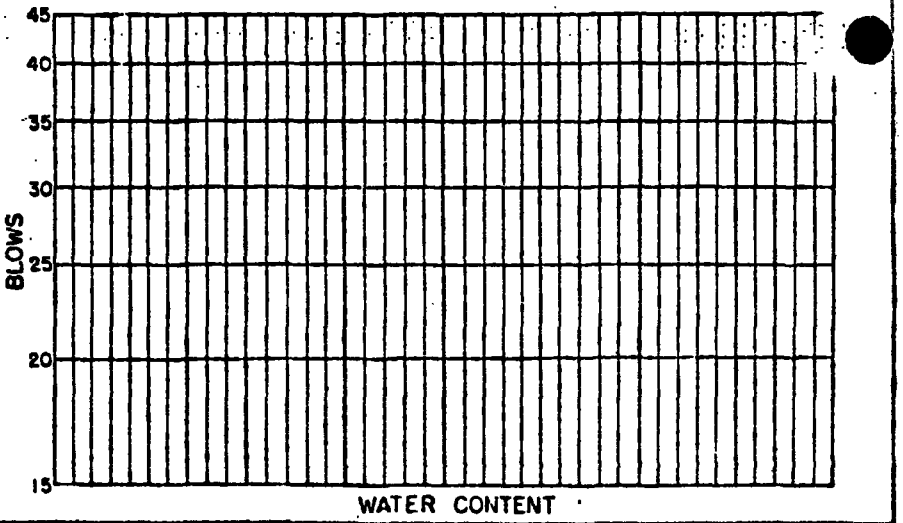


PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

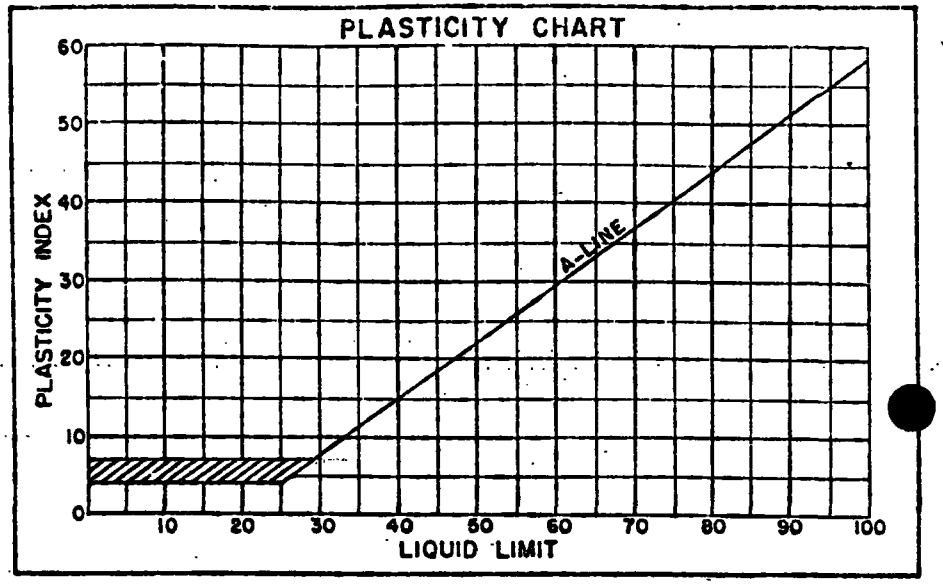
SAMPLE NO. 5880-14 JOB NO. C2637 HOLE NO. 2
DATE 4-17-85 OPERATOR LD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, F Gravelly, V SLTY, [redacted] C, -vn-F SAND

PLASTICITY CHART

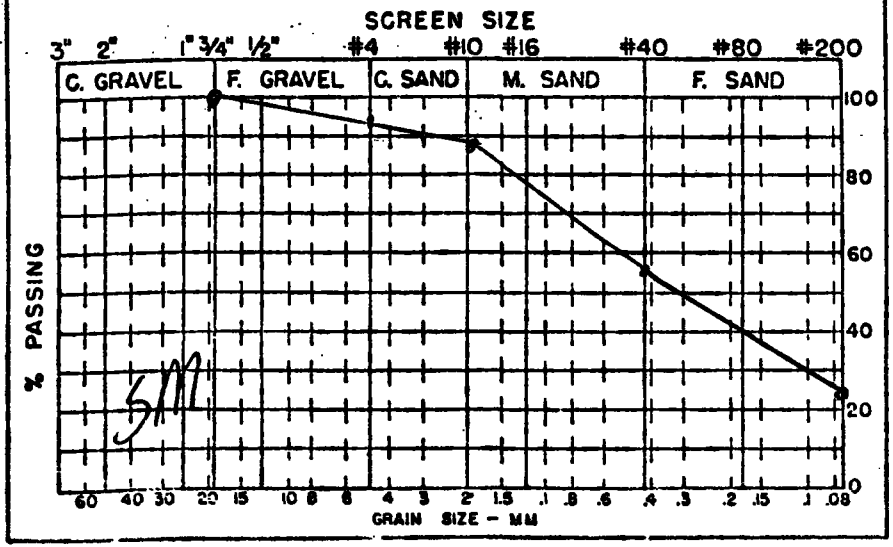


31.1 37.7 21.2

SIEVE ANALYSIS % Passing 25.6

		-40	44.0	57.4
-¾	9.0	100	-80	
-4	4.8	92.8	-140	
-10	39.7	89.0	-200 28.1	72.4

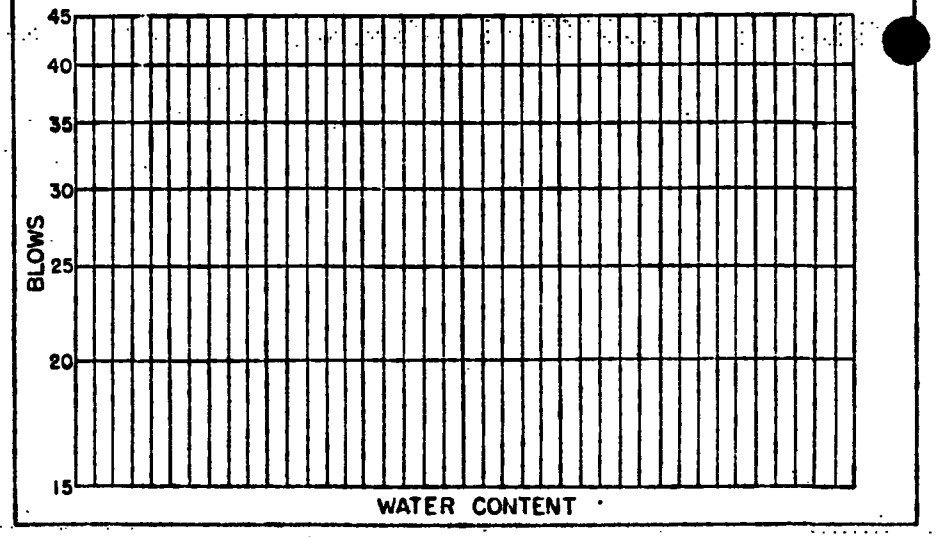
GRAIN SIZE CURVE



SM

LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 588015 JOB NO. 2637 HOLE NO. 2

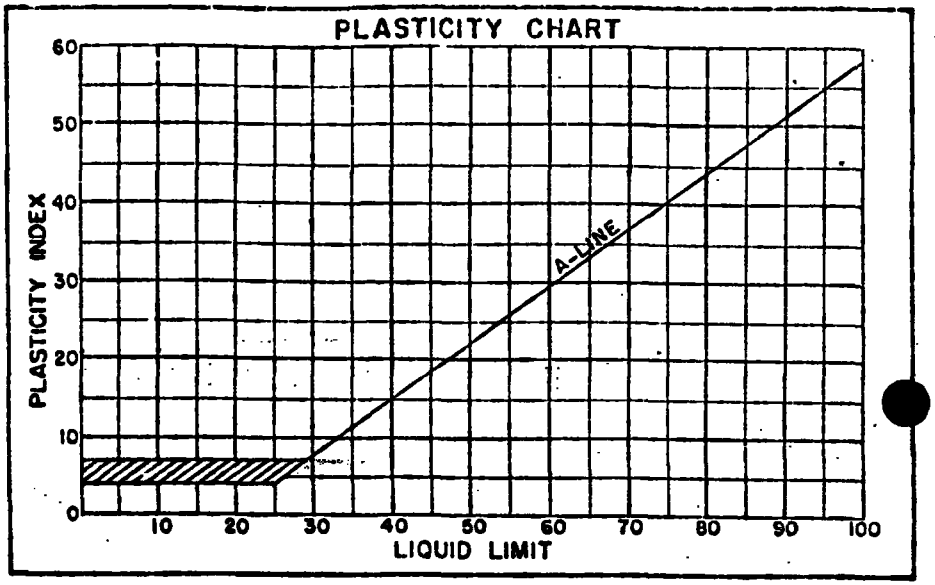
DATE 4-17-85 OPERATOR [illegible]

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, SLTY, C-F Gravelly C-M-F SAND

PLASTICITY CHART

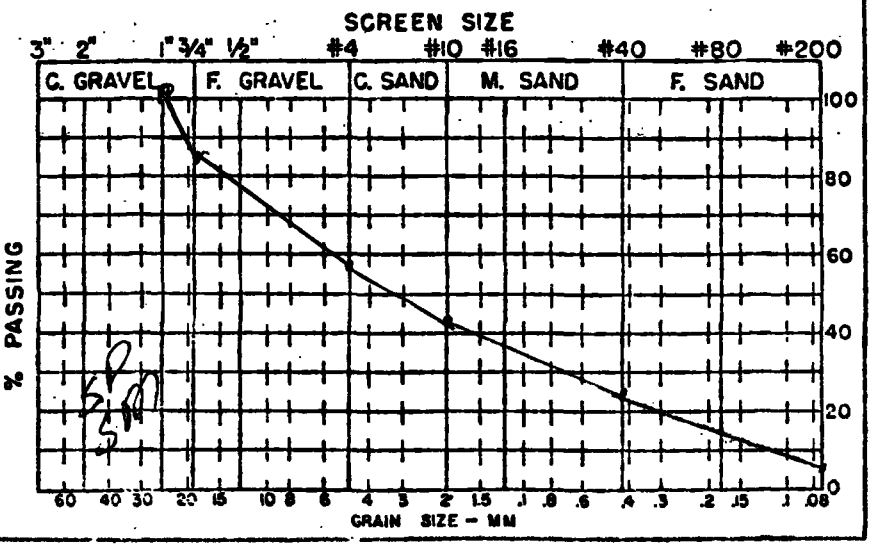


43.4 48.0 10.6

SIEVE ANALYSIS % Passing 185.75

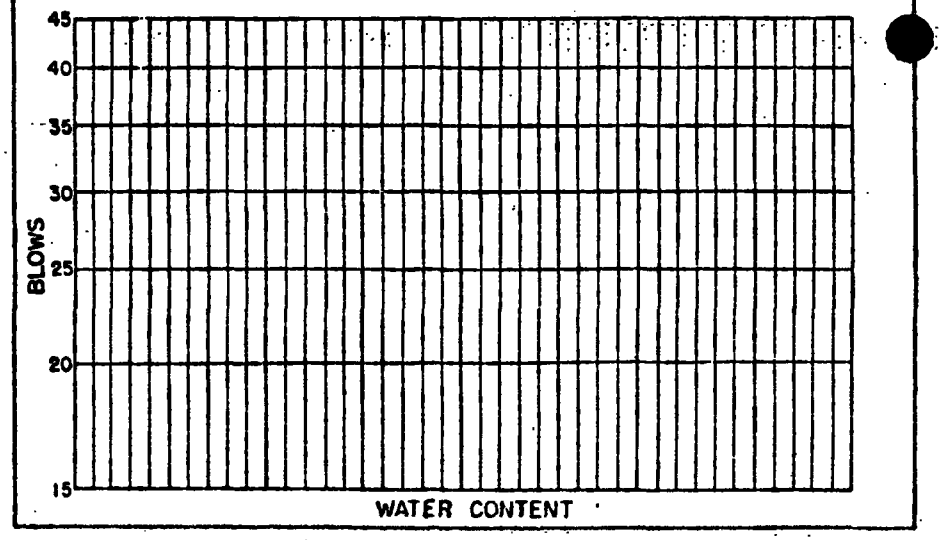
1 38.75	100	-40 30.7	23.2	
-¾ 47.8	84.4	-80		
-4 31.5	58.7	-140		
-10 34.6	41.8	-200 12.4	6.7	

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
%H_2O					PL=
Blows					PI=



WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Seattle

Date February 25, 1985

Dear Sir:

I have forwarded by today's Hand Carried the following DISTURBED Foundation Samples.

Contract or Job No. C-2637 Section Sunset Blvd. to Factoria I/C SR No. 405 Sub-Section

Station & Offset 377+50 70'LT ℄ Hole # 3

E Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
5879-1	P-1	-1.0' to -3.0'	H2O = 5.3	SP	
-2	P-2	-3.0' to -5.0'	H2O = 4.4	SP	
-3	P-3	-5.0' to -7.0'	H2O = 10.1	SP	
-4	P-4	-7.5' to -9.5'	H2O = 11.7	SP SM	
-5	P-5	-10.0' to -12.0'			LK5879-4
-6	P-6	-12.5' to -14.5'	H2O = 11.7	SP SM	
-7	P-7	-15.0' to -17.0'			LK5879-6
-8	P-8	-17.5' to -19.5'	H2O = 17.1	SM	
-9	P-9	-20.0' to -22.0'			LK5879-8

1 copy with samples
1 copy to addressee

Yours very truly,

KEW (RMM)

Inspector.

DOT FORM 351-002 REVISED 2/80

WASHINGTON STATE
DEPARTMENT OF TRANSPORTATION

MATERIALS ENGINEER
Materials Laboratory
P. O. Box 167, Olympia, WA 98504 (Mailing Address)
1655 So. 2nd Ave.
Tumwater, Washington 98504 (Shipping Address)

Place Seattle

Date February 25, 1985

Dear Sir:

I have forwarded by today's Hand Carried the following DISTURBED Foundation Samples.

Contract or Job No. C-2637 Section Sunset Blvd. to Factoria I/C SR No. 405 Sub-Section

Station & Offset 377+50 70'LT ℄ Hole # 3

E Lab No.	Drive #	Depth	Tube Position in Sampler	Clas.	Description
5879-10	P-10	-22.5' to -23'9"	H2O = 8.8	SP SM	
-11	P-11	-25.0' to -27.0'			LK5879-10

1 copy with samples
1 copy to addressee

Yours very truly,

KEW (RMM)

Inspector.

DOT FORM 351-002 REVISED 2/80

3

SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5874-1 JOB NO. C2637 HOLE NO. 3

DATE 4-17-85 OPERATOR AD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

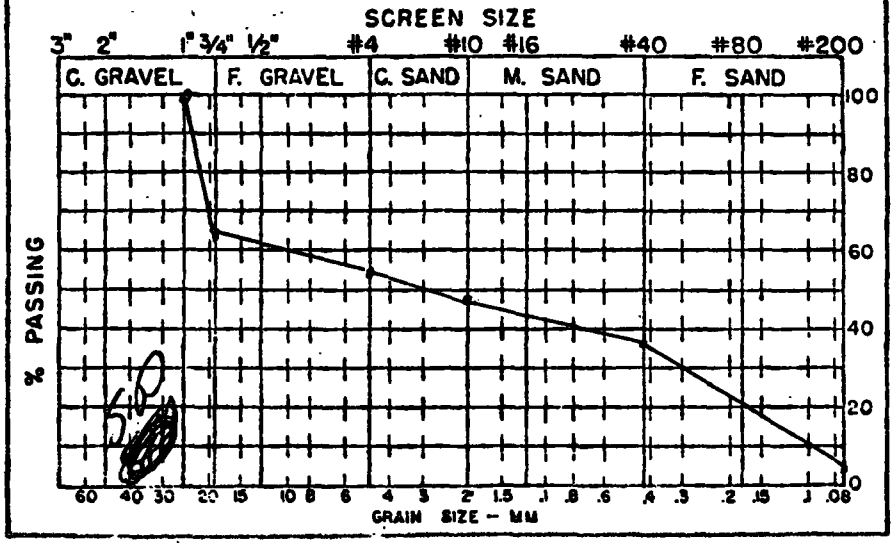
DESCRIPTION: Brn, Dry, SLY SLTY C-F Gravelly [redacted] C, M-F SAND

43.35 45.65 5.3

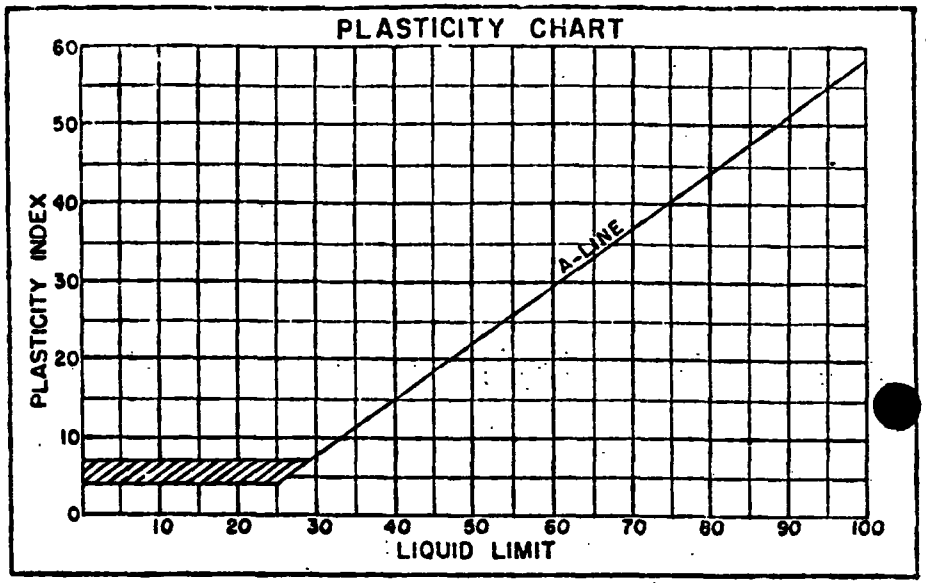
SIEVE ANALYSIS % Passing 213.4

-1	77.7	100	-40	72.1	37.4
-3/4	21.7	63.5	-80		
-4	9.4	53.4	-140		
-10	24.85	49.10	-200	7.65	3.58

GRAIN SIZE CURVE

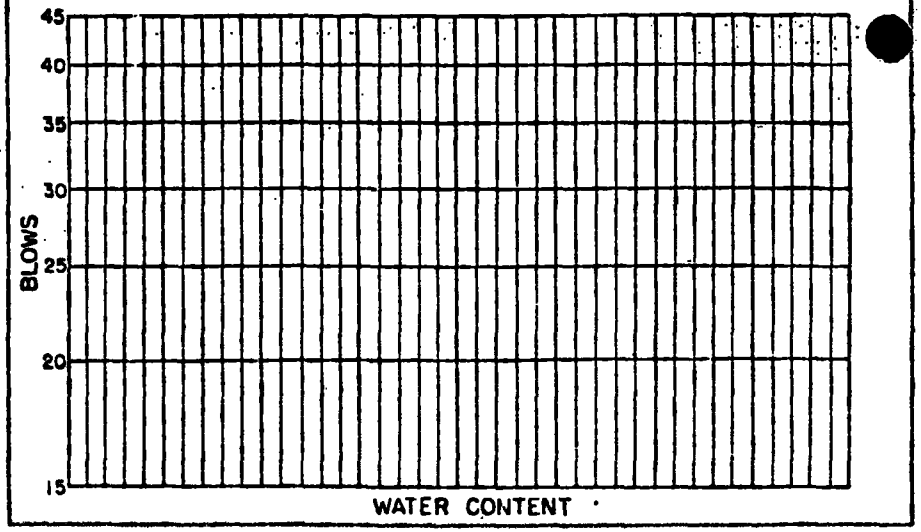


PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

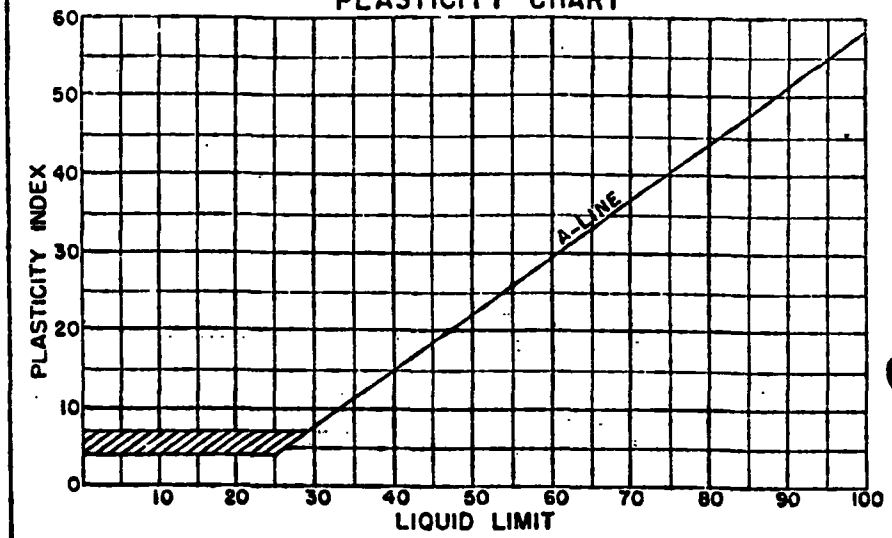
SAMPLE NO. 5879-2 JOB NO. C2637 HOLE NO. 3
DATE 4-17-85 OPERATOR ID

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, Dry, SLY SLTY, F Gravelly, C, M-F SAND

PLASTICITY CHART

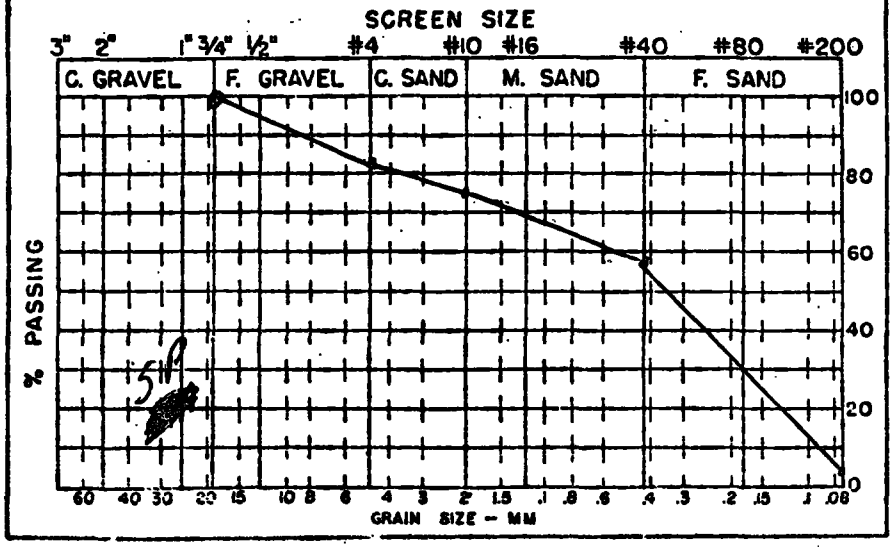


49.7 51.9 4.4

SIEVE ANALYSIS % Passing 99.3

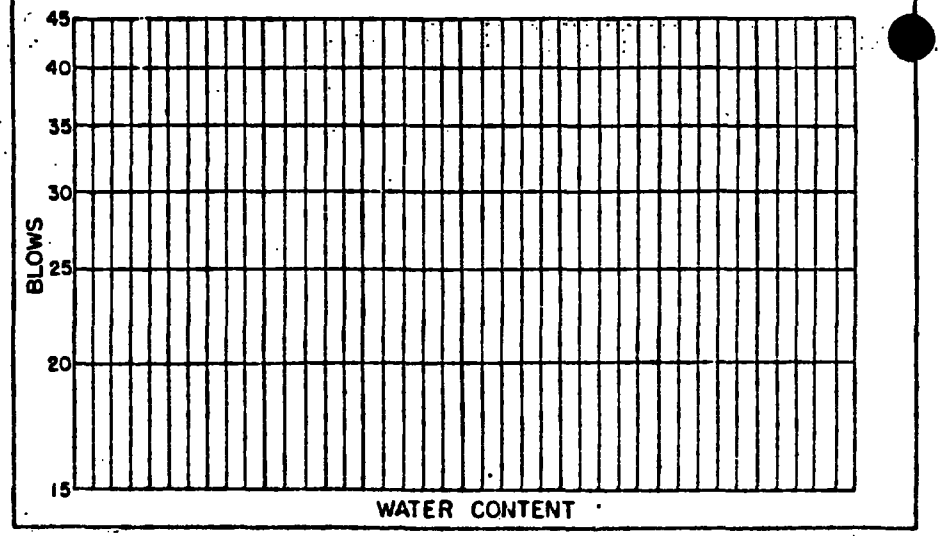
			-40	54.0	58.1
-3/4	18.85	100	-80		
-4	4.75	80.9	-140		
-10	18.0	76.2	-200	3.7	3.7

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. SB74-3 JOB NO. 82637 HOLE NO. B

DATE 4-17-85 OPERATOR SD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

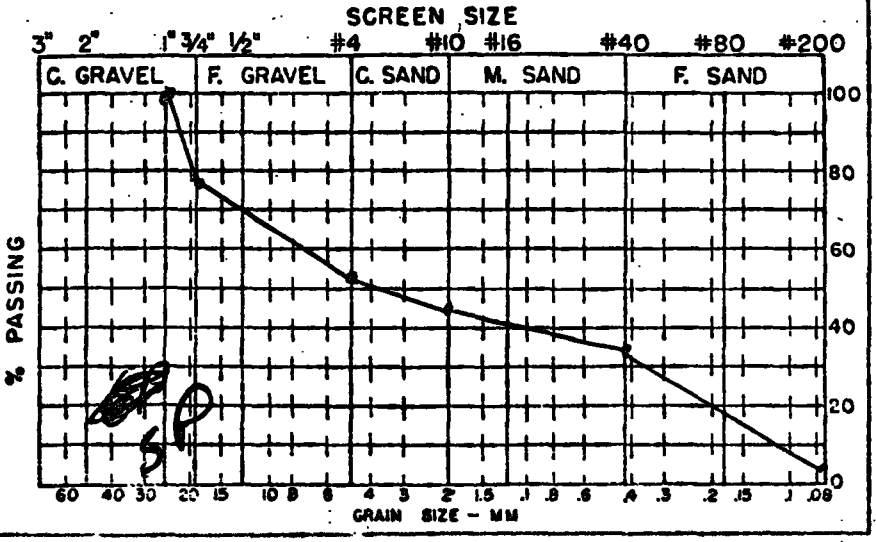
DESCRIPTION: Brn, Moist, SLY SCLY, C-F Grained, C-M-F SAND

52.05 52.3 49.1

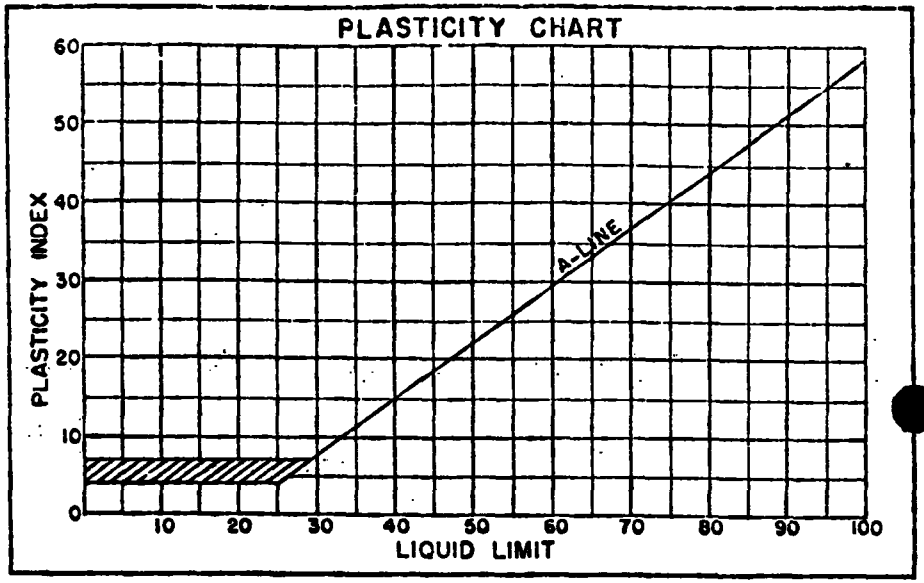
SIEVE ANALYSIS

			% Passing	51.0
-1 44.7	100	-40	60.8	33.2
-¾ 56.1	98.7	-80		
-4 11.5	52.1	-140		
-10 28.6	46.7	-200	9.3	4.9

GRAIN SIZE CURVE

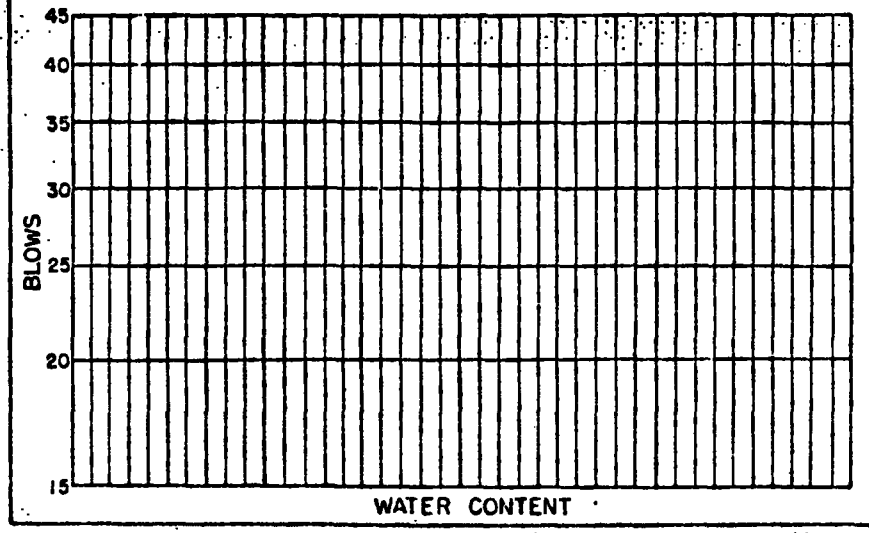


PLASTICITY CHART



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

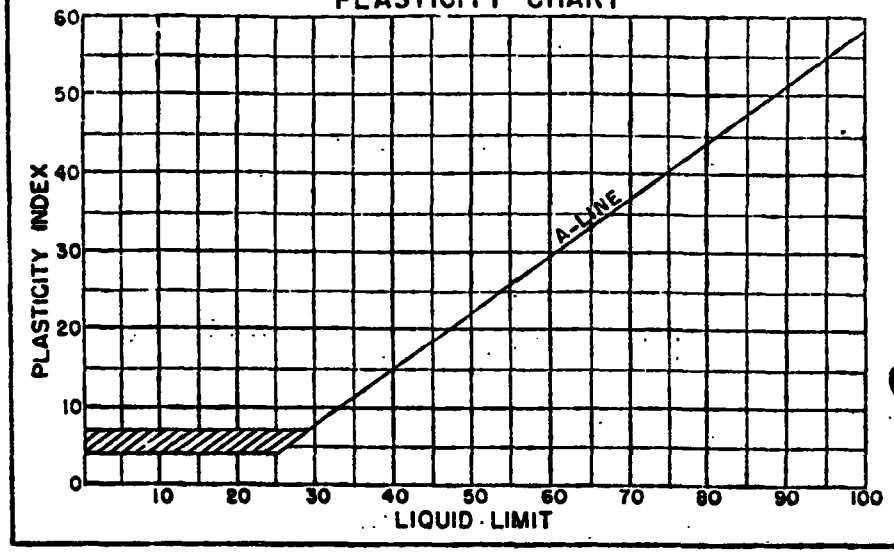
SAMPLE NO. 5879-4 JOB NO. C2637 HOLE NO. J
DATE 4-17-85 OPERATOR [illegible]

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn Moist SLY SLTY
C-F Gravel, Cm-F SAND

PLASTICITY CHART

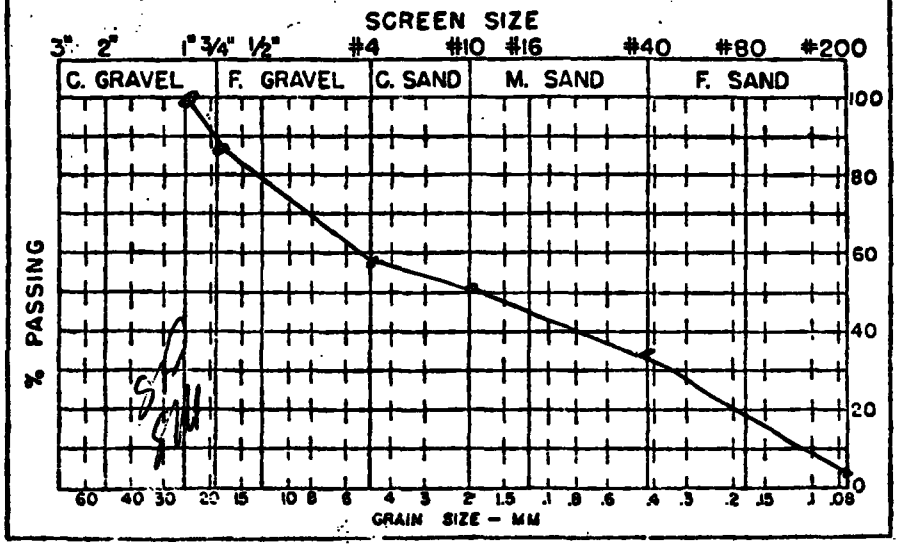


51.35 57.4 11.7

SIEVE ANALYSIS % Passing 128.9

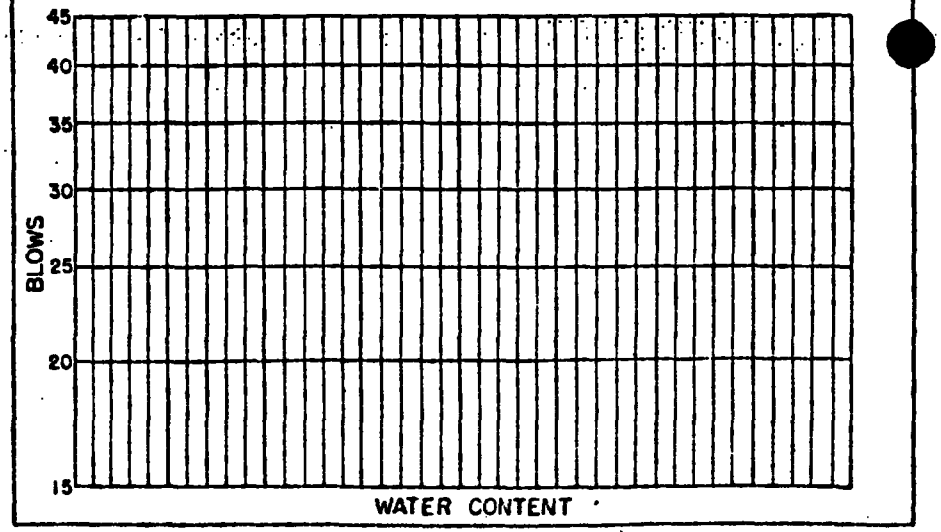
-1	21.0	100	-40	51.65	34.3
-3/4	52.0	88.3	-80		
-4	15.2	59.2	-140		
-10	29.4	50.7	-200	9.65	5.4

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. SB79-6 JOB NO. C3637 HOLE NO. 3

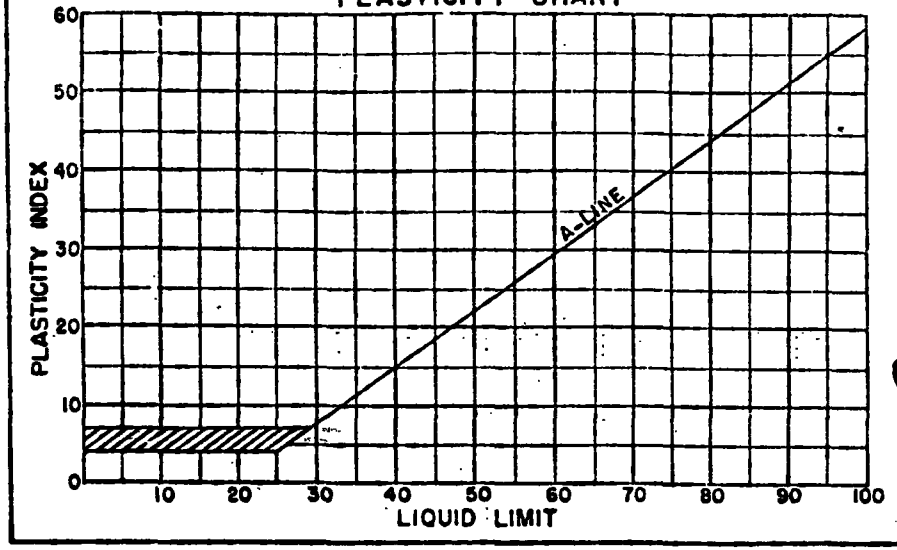
DATE 4-17-95 OPERATOR JD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, moist, Silty, F Gravelly, C-M-F Sand

PLASTICITY CHART



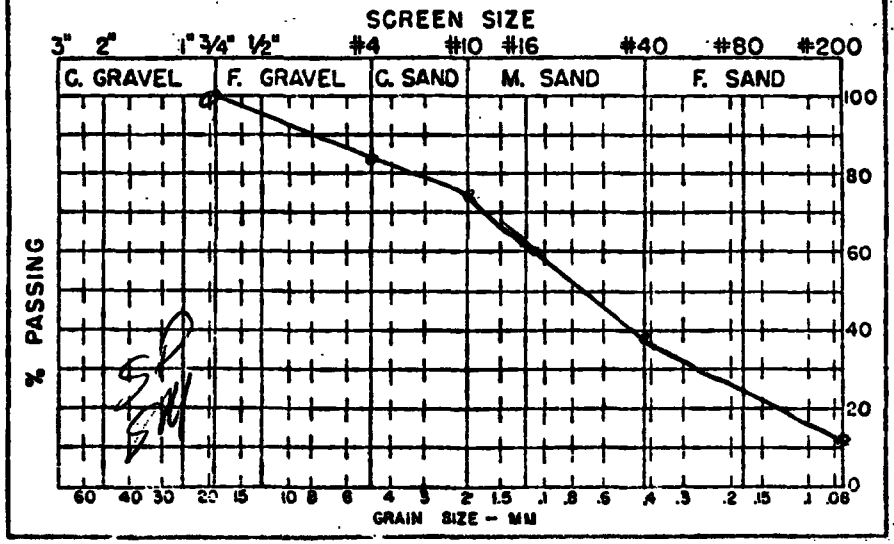
33.75 37.7 11.7

SIEVE ANALYSIS

% Passing 110.2

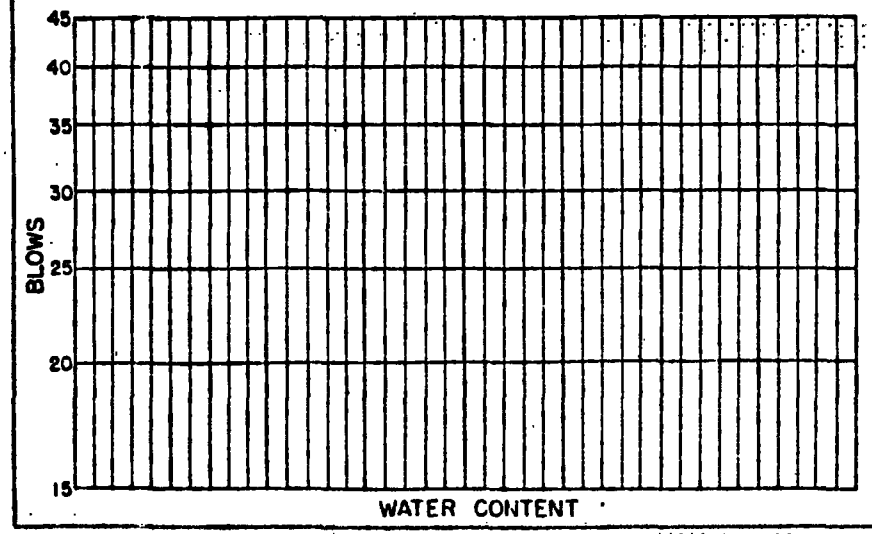
			-40	30.6	39.5
-¾	18.5	100	-80		
-4	8.7	83.1	-140		
-10	39.35	75.2	-200	13.05	11.8

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5879-8 JOB NO. 02637 HOLE NO. 3

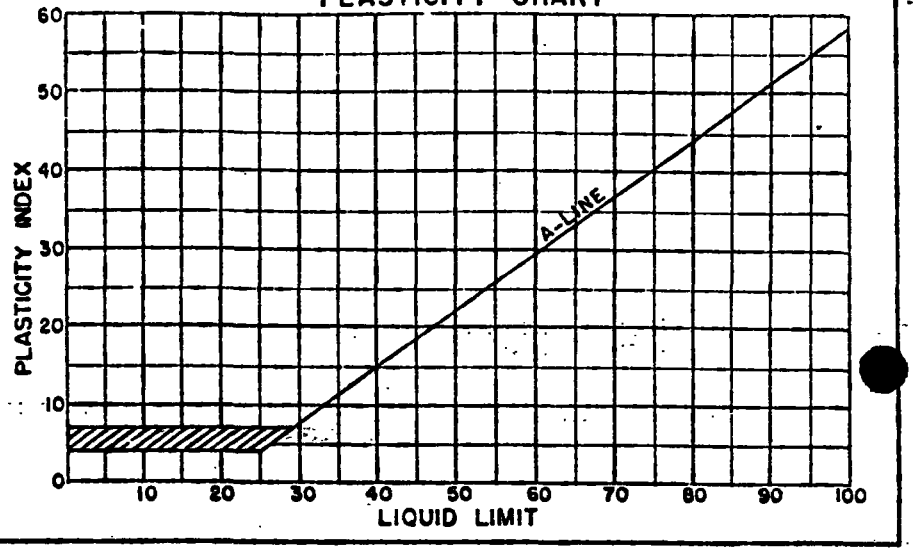
DATE 4-17-85 OPERATOR MD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn moist, SLTY, SAND, F-M-F SAND

PLASTICITY CHART

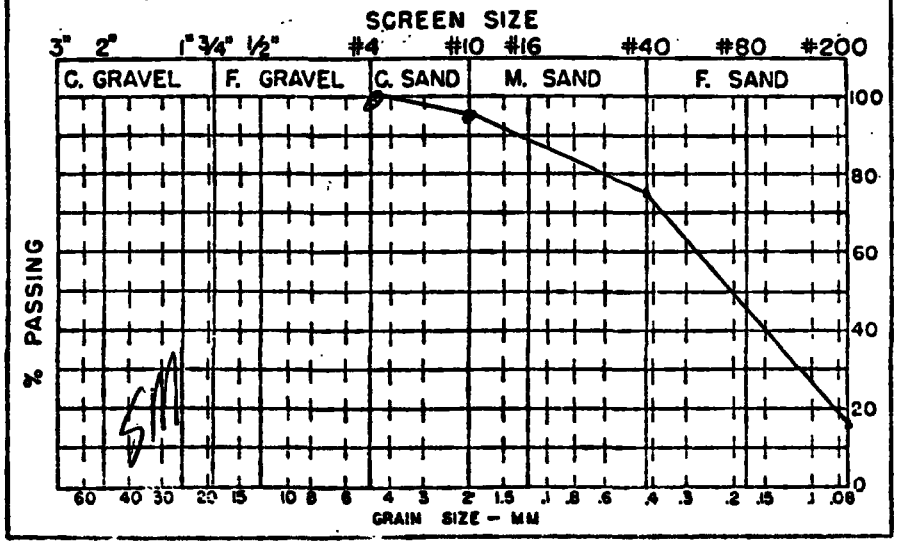


4335 50.8 17.1

SIEVE ANALYSIS % Passing 109.0

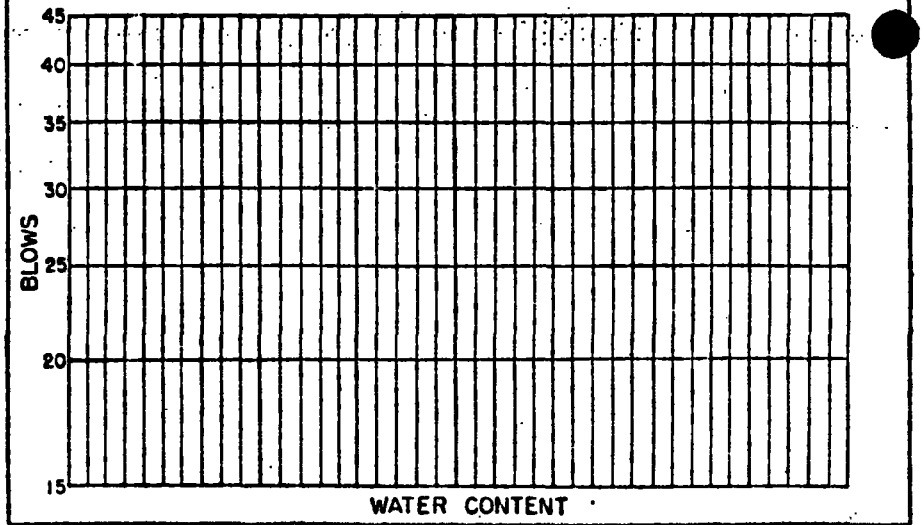
			-40	60.3	73.8
-¾			-80		
-4	3.3	100	-140		
-10	25.25	96.9	-200	20.15	18.5

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



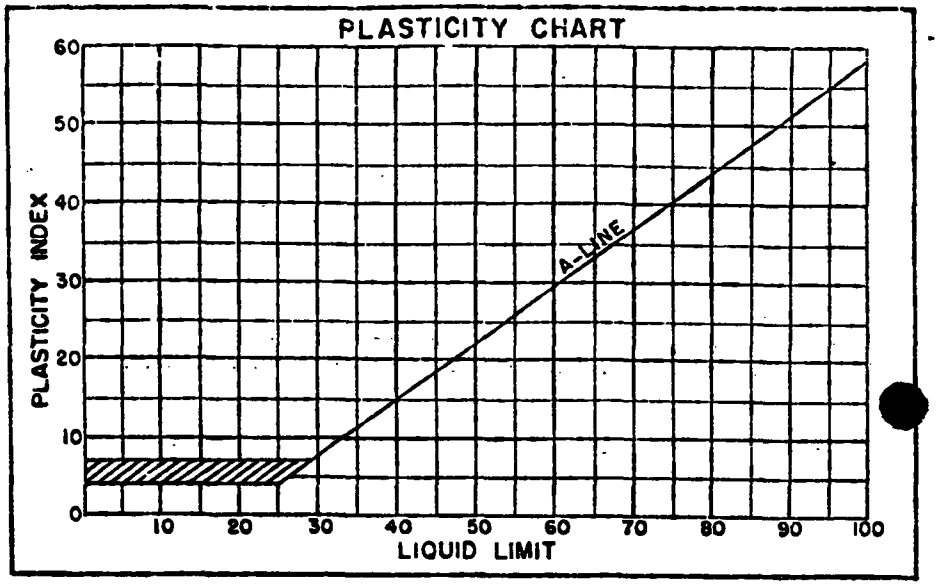
SOIL CLASSIFICATION AND IDENTIFICATION WORKSHEET

SAMPLE NO. 5879-10 JOB NO. C2637 HOLE NO. 3
DATE 4-17-85 OPERATOR RD

SOIL FIELD IDENTIFICATION

TEST	SAND	SILT	CLAY
VISUAL	✓	✓	
DRIED CAST			
DILATANCY			
BITE			
TOUGHNESS			

DESCRIPTION: Brn, Dry, SLTY, F Gravelly, c-m-F SAND

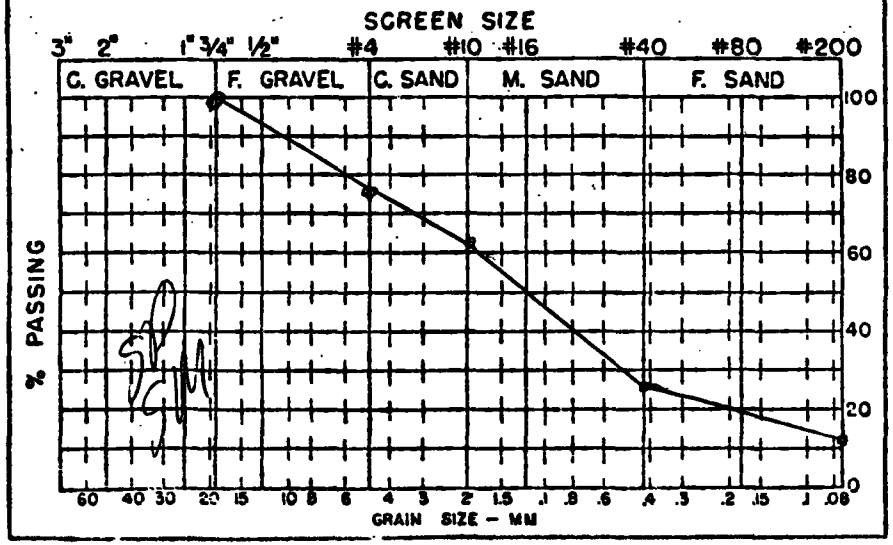


42.0 51.15 8.8

SIEVE ANALYSIS % Passing 160.2

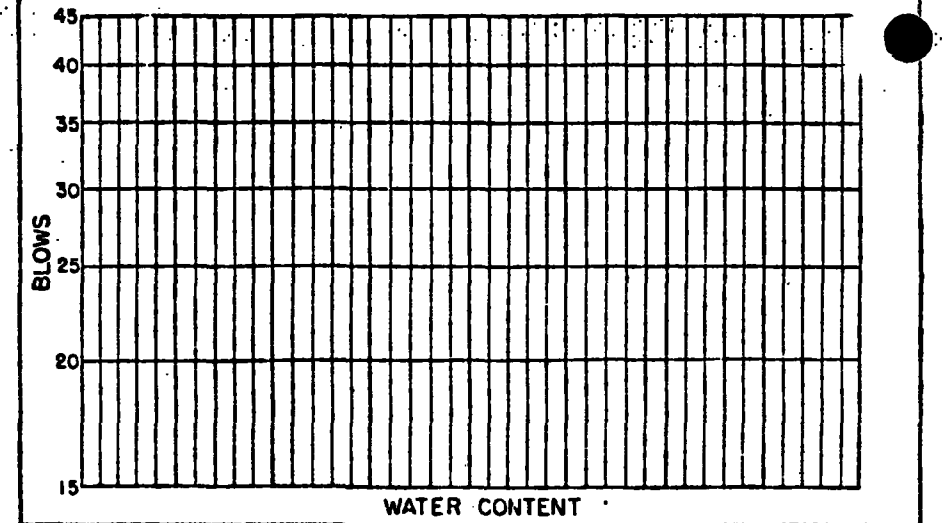
		-40	25.1	27.1
-3/4	36.4	100	-80	
-4	24.25	77.2	-140	
-10	55.7	61.8	-200	18.25 11.4

GRAIN SIZE CURVE



LIQUID LIMIT DETERMINATION

	LIQUID LIMIT				PLASTIC LIMIT
Can No.					
Wet Wt.					
Dry Wt.					
% H_2O					PL=
Blows					PI=



FLATIRON | LANE | wood.

In Association with

Appendix C
Grade Separation Barrier 05.33R Calculations

APPENDIX C - GRADE SEPARATION BARRIER 05.33R CALCULATIONS

General

This appendix presents geotechnical calculations for Grade Separation Barrier 05.33R including:

- ESU Soil Properties
- Seismic Hazard Analysis
- Lateral Earth Pressures
- Coefficients of Friction for Sliding
- Bearing Resistance and Elastic Settlement
- Global Stability

ESU Soil Properties

Design soil properties were developed in accordance with the Project GDM, AASHTO LRFD, and FHWA. We calculated the average, geometric mean, and standard deviation within each ESU. We verified the reliability of the ESU data set by comparing the COV of each calculated geometric mean value to measured and interpreted values presented in Sabatini et al. (2002) Table 52.

A detailed description of the soil property development is presented in Section 7.1 of this geotechnical engineering report. Supporting calculations are provided in this appendix.

Seismic Hazard Analysis

We selected a representative site class for the barrier from the site class evaluation of nearby borings. We evaluated the site class of each boring using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 3.10.3.1.

We developed seismic design parameters using the WSDOT Bridge Engineering Software BEToolbox/BridgeLink in accordance with the WSDOT BDM based on the projected ground motion at the project site that has a 7 percent (SEE) probability of exceedance in a 75-year period (approximate 1,000-year return period).

We used a mean earthquake magnitude at the PGA period of 7.0 for the SEE based on the Hart Crowser design report “I-405 R2B Segment 1a Site-Specific Hazard Analysis RFU,” dated March 25, 2021.

We evaluated the FS against liquefaction and liquefaction-induced settlement of saturated, loose to medium dense soils in accordance with the Project GDM Chapter 6 using a spreadsheet developed by GeoEngineers. The FSs against liquefaction at Grade Separation Barrier 05.33R were greater than 1.2 for all soil analyzed; per Project GDM Section 6-4.2.3, soils with liquefaction potential are defined as those with FSs against liquefaction less than 1.2.

Detailed descriptions of our seismic hazard analysis methodology and the results are presented in Section 7.2 and Section 8.1, respectively, of this report. Site class calculations, WSDOT BDM software outputs, and liquefaction analyses are provided in this appendix.

Lateral Earth Pressures

Active lateral pressure coefficients and active lateral earth pressures for imported common borrow, select borrow, and gravel borrow were calculated in accordance with AASHTO LRFD Section 3.11.5 using a 4H:21V barrier back face batter, the proposed 3.2H:1V backslope behind the wall, and a horizontal foreslope in front of the wall. Lateral earth pressures shall be applied using a triangular distribution. An LRFD load factor of 1.5 shall be applied to the active earth pressures in accordance with AASHTO LRFD Table 3.4.1-2. Due to negligible embedment of the wall, passive lateral earth pressures shall be ignored.

Surcharge loads and appropriate load factors from AASHTO LRFD Tables 3.4.1-1 and 3.4.1-2 shall be applied to evaluate barrier stability.

A detailed description of our analysis methodology and the calculated results are presented in Section 7.3 and Section 8.2, respectively. Supporting calculations are provided in this appendix.

Coefficients of Friction for Sliding

Coefficients of friction for sliding on surficial native soils, common borrow, select borrow, and gravel borrow were calculated using AASHTO LRFD equation 10.6.3.4-2.

A detailed description of our analysis methodology and the results are presented in Section 7.4 and Section 8.3, respectively, of this report. Supporting calculations are provided in this appendix.

Bearing Resistance and Elastic Settlement

We estimated the bearing resistance and elastic settlement of the barrier using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 10.6.3. We estimated elastic settlement from procedures outlined in AASHTO LRFD and Section 10.6.2.4. Sliding and overturning are being evaluated by the design-build team's wall designers and will be submitted under separate cover.

A detailed description of our analysis methodology and the results are presented in Section 7.5 and Section 8.4, respectively, of this report. Supporting calculations are provided in this appendix.

Global Stability

We performed global stability analyses for the following critical design section:

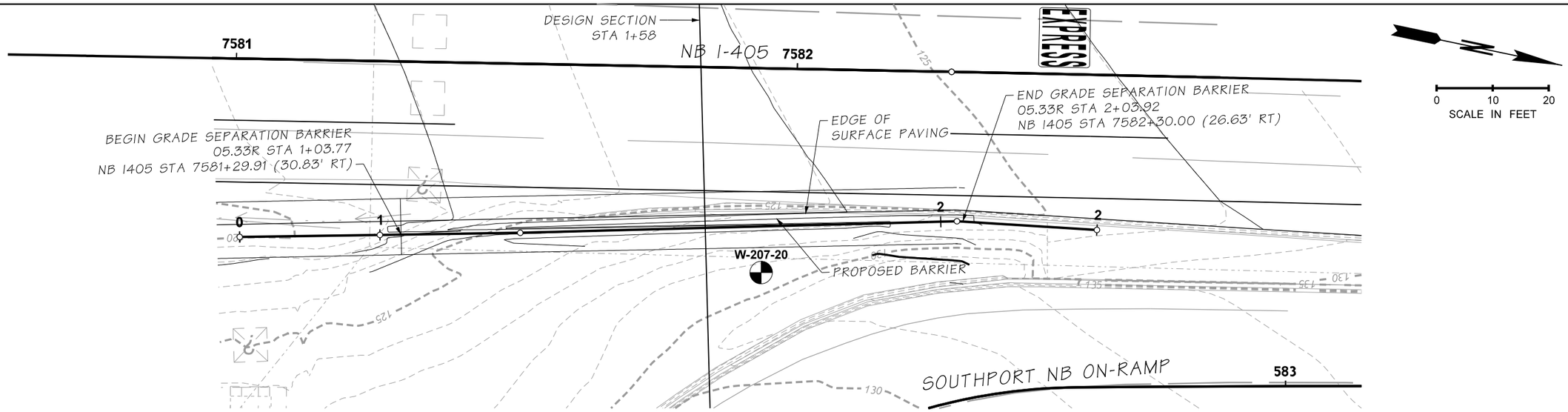
- Section Sta. 1+58 – Maximum overall slope height

Global stability was evaluated using limit equilibrium analysis methodology outlined in the Project GDM using the computer design software Slope/W (Geo Slope International, Ltd. 2020). We analyzed FSs using Spencer's method and Morgenstern-Price for a circular failure surface.

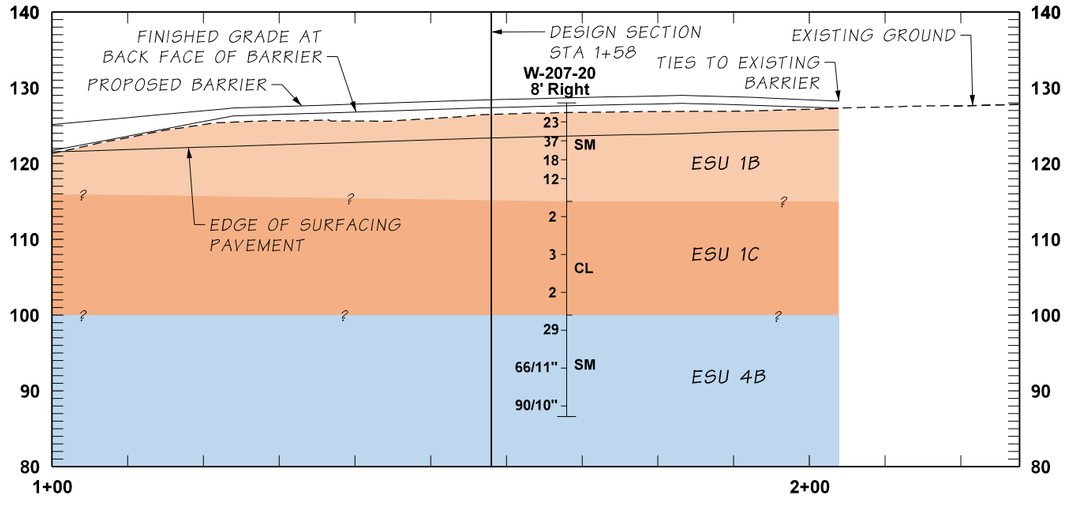
Grade Separation Barrier 05.33R will be designed in accordance with WSDOT BDM Section 10.3.1 for differential grade concrete barriers of 4 feet or less and will follow procedures in Project GDM Chapter 9 for embankments to evaluate global stability. Per Project GDM Section 9.2.3.1, seismic global stability analyses are not required for the barrier since it will not support or potentially impact structures.

Detailed descriptions of our global stability analysis methodology and the results of our analyses are presented in Section 7.8 and Section 8.6, respectively, of this report. Global stability models showing FS for critical failures at the design section are provided in this appendix. Slope/W reports are provided in Appendix J.

Appendix C.1 - Grade Separation Barrier 05.33R Plan, Profile and Sections



PLAN - GRADE SEPARATION BARRIER 05.33R



REFLECTIVE ELEVATION - GRADE SEPARATION BARRIER 05.33R

DATUM

(NAVD) 88

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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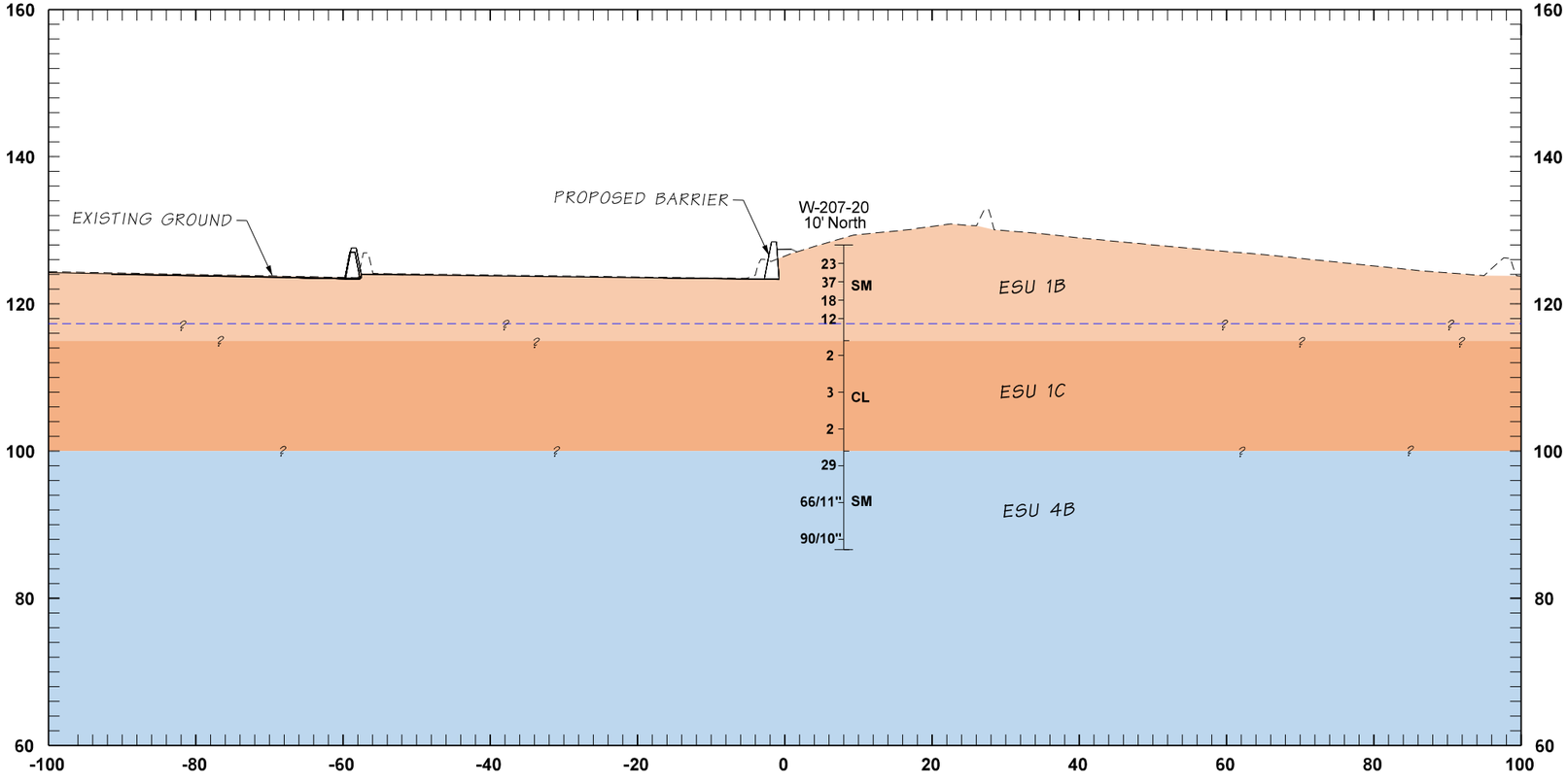
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN AND ELEVATION
GRADE SEPARATION BARRIER 05.33R

PLAN REF NO

SHEET 1 OF 1 SHEETS



GRADE SEPARATION BARRIER 05.33R STATION 1+58

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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GRADE SEPARATION BARRIER 05.33R DESIGN SECTION AT STA. 1+58

PLAN REF NO

SHEET 1 OF 1 SHEETS

Appendix C.2 - Grade Separation Barrier 05.33R ESU Soil Property Calculations

05.33R

Soil Properties Summary

ESU	Description	Total No. of Samples [b]	USCS [c]	Fines [d] (%)	Plasticity Index, PI [e] (%)	Raw N (bpf)	N_{60} [f] (bpf)		$(N_1)_{60}$ [f] (bpf)		Total Unit Weight [g] (pcf)		Effective Friction Angle, ϕ' [h] (deg)		Fully Softened ϕ' [i] (deg)	Effective c' [j] (psf)	Residual ϕ' [k] (deg)	Residual Shear Strength, Sr (psf)	Undrained Shear Strength, Su (psf)	
				Value	Value	Value	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	Value	Value	Value	Value	COV
1B	Medium Dense to Very Dense Coarse-Grained Fill	3	SM	34	-	17	23	25%	33	39%	120	6%	36	4%	-	-	-	-	-	-
1C	Very Soft to Medium Stiff/Very Loose to Loose Fine-Grained Fill	3	CL	50	8	2	4	25%	4	25%	115	0%	27	4%	-	-	-	-	-	-
4B	Dense to Very Dense Sand/Gravel	2	SM	28	-	93	145	19%	136	17%	130	0%	43	2%	-	-	-	-	-	-

Notes:

a. Coefficient of Variation (COV) percentage calculated to verify the variability and reliability of sample data within ESU (WSDOT GDM Section 5.11.2 (2015)). Calculated COV percentage compared to ranges presented in Table 52 (Sabatini et al. 2002) (below).
b. Number of samples excludes outliers.
c. Predominant USCS classification of all samples in ESU. Sandstone, where encountered, denoted as (SS).
d. Fines content percentage calculated as the geometric mean of all samples, whose values were determined through lab testing or estimated from field classification.
e. For coarse-grained ESUs, the plasticity index was estimated from the fine-grained portion of the soil. For fine-grained ESUs, if lab data is limited, the plasticity index may not be representative of the overall soil unit.
f. Corrected blow counts (N_{60} and $(N_1)_{60}$) were calculated following WSDOT GDM Section 5.5 (2015).
g. Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Unit weight data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.
h. Design friction angles were selected by considering fines content. Friction angle data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.
i. Where applicable, fully softened friction angle was estimated following WSDOT GDM, Figure 5-7 (After Stark and Hussain, 2013).
j. Where applicable, effective cohesion was calculated using Equations 6 through 8 in the WOOD Geotechnical SPM.
k. Where applicable, residual friction angle (to be used for slope stability evaluation) was estimated following WSDOT GDM, Figure 5-5 (After NAVFAC, 1971).

Measured or interpreted parameter value	Coefficient of Variation, V (%)
Unit weight, γ	3 to 7 %
Buoyant unit weight, γ_b	0 to 10 %
Effective stress friction angle, ϕ'	2 to 13 %
Undrained shear strength, s_u	13 to 40 %
Undrained strength ratio (s_u/σ_v')	5 to 15 %
Compression index, C_c	10 to 37 %
Preconsolidation stress, σ_p'	10 to 35 %
Hydraulic conductivity of saturated clay, k	68 to 90 %
Hydraulic conductivity of partly-saturated clay, k	130 to 240 %
Coefficient of consolidation, c_v	33 to 68 %
Standard penetration blowcount, N	15 to 45 %
Electric cone penetration test, q_c	5 to 15 %
Mechanical cone penetration test, q_c	15 to 37 %
Vane shear test undrained strength, s_{uVST}	10 to 20 %

Source: Table 52 (Sabatini et al. 2002)

	ESU Name:	ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill									
		N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	17	23	33	34	-	41	36	120	-	-
	Average:	18	23	34	34	-	41	36	120	-	-
	St. Dev.:	5.5	5.9	13.5	-	-	1.7	1.7	7.6	-	-
	COV:	0.31	0.25	0.39	-	-	0.04	0.05	0.06	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-207-20	125.7	23	29	49	37	-	42	37	130	-	-	SM	
W-207-20	123.2												rock in barrel, SPT may be artifically high
W-207-20	120.7	18	24	32	34	-	41	36	120	-	-	SM	
W-207-20	118.2	12	17	22	31	-	39	34	115	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained shear strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties or using the average of two tested samples

4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill

1. Check N160 COV is between 15 and 45%

Selected Design N160:	33
Coefficient of Variation (COV):	0.39

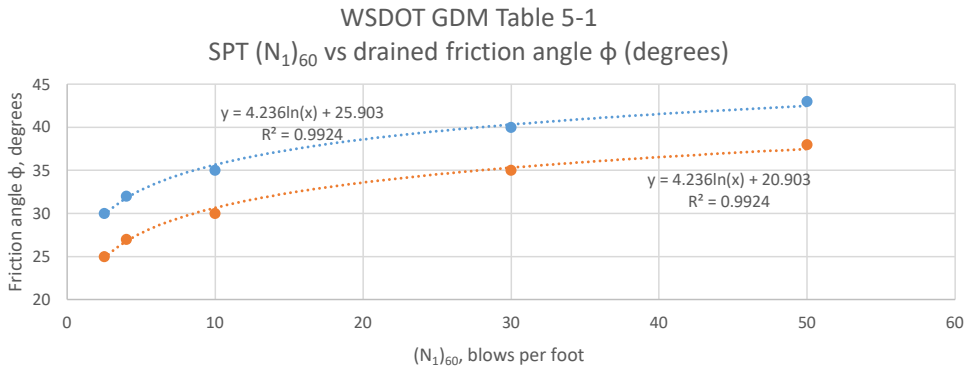
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	41	36	38

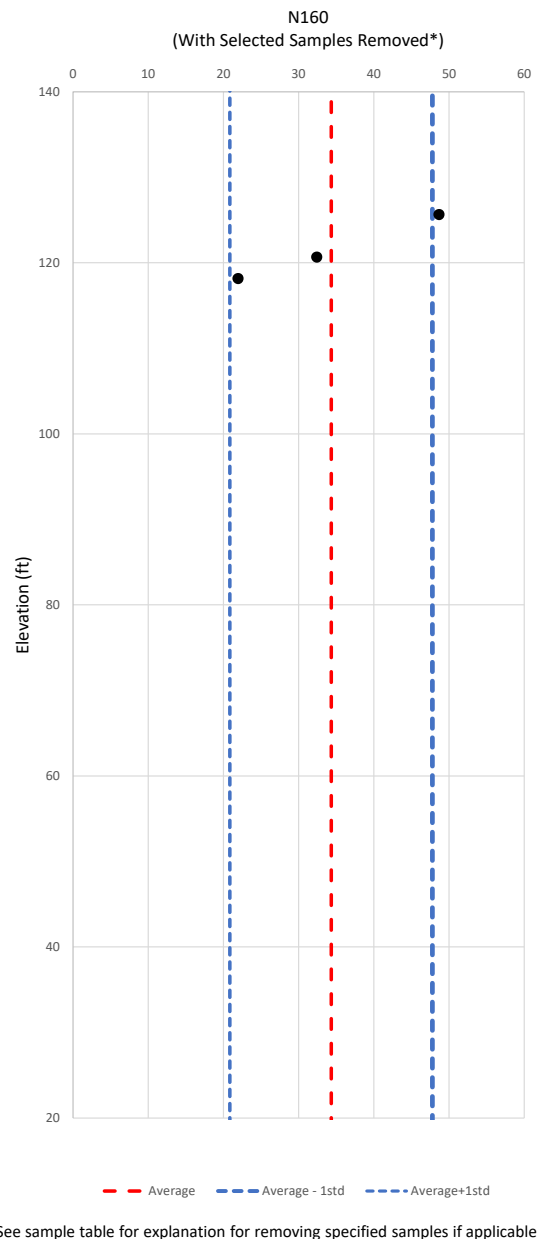
ϕ' COV
0.04

Selected Design Phi' (deg):	36
Notes on Selection:	The estimated fines content is 34% (geomean). The high fines content supports the use of the lower bound of the friction angle range.

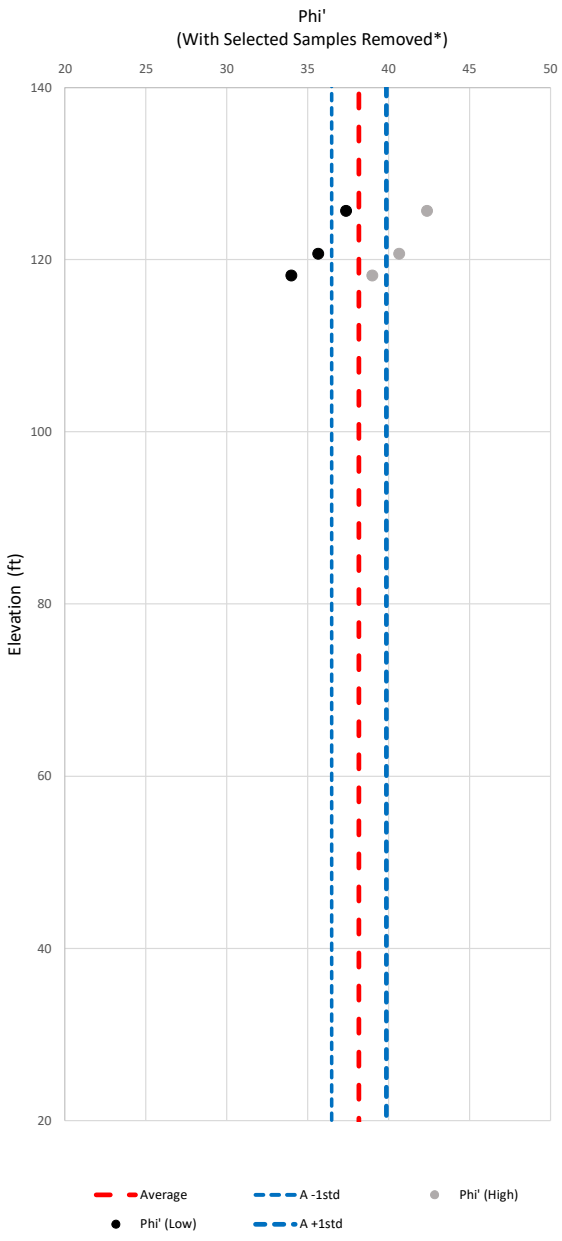
Pick Representative USCS:	SM
Pick Representative Unit Weight:	120
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 6%.

*Using Predominant USCS Classification

ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill



*See sample table for explanation for removing specified samples if applicable



ESU Name:	ESU 1C - Very Soft to Medium Stiff/Very Loose to Loose Fine-Grained Fill									
	N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
GeoMean:	2	4	4	50	8	32	27	115	-	-
Average:	2	4	4	50	8	32	27	115	-	-
St. Dev.:	0.6	0.9	1.0	-	-	1.0	1.0	0.0	-	-
COV:	0.25	0.25	0.25	-	-	0.03	0.04	0.00	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-207-20	113.2	2	3	4	50	8	32	27	115	-	-	CL	
W-207-20	108.2	3	5	5	50	-	33	28	115	-	-	CL	
W-207-20	103.2	2	3	3	50	-	31	26	115	-	-	CL	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained shear strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties or using the average of two tested samples
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 1C - Very Soft to Medium Stiff/Very Loose to Loose Fine-Grained Fill

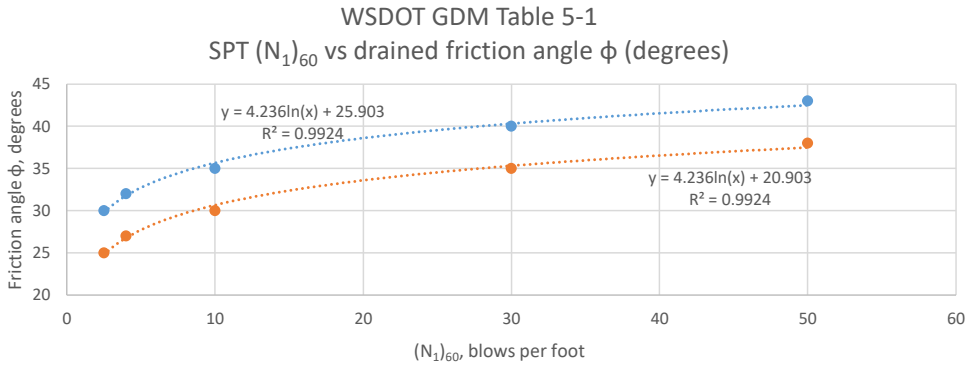
1. Check N160 COV is between 15 and 45%

Selected Design N160:	4
Coefficient of Variation (COV):	0.25

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43



* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)

	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	32	27	29

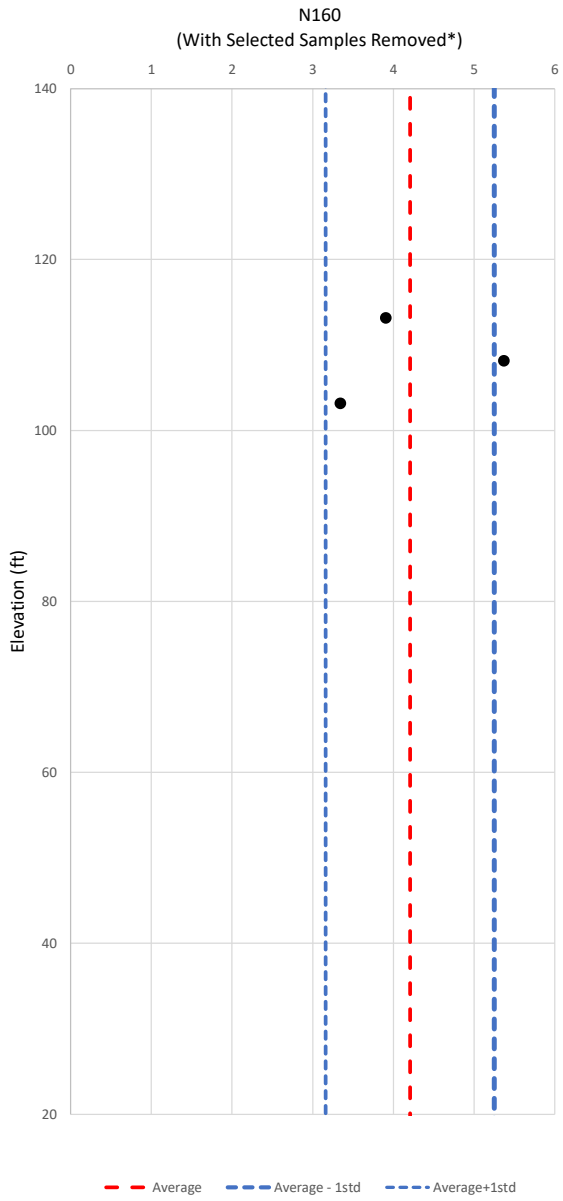
ϕ' COV
0.04

Selected Design Phi' (deg):	27
Notes on Selection:	The estimated fines content is 50% (geomean). The high fines content supports the use of the lower bound of the friction angle range.

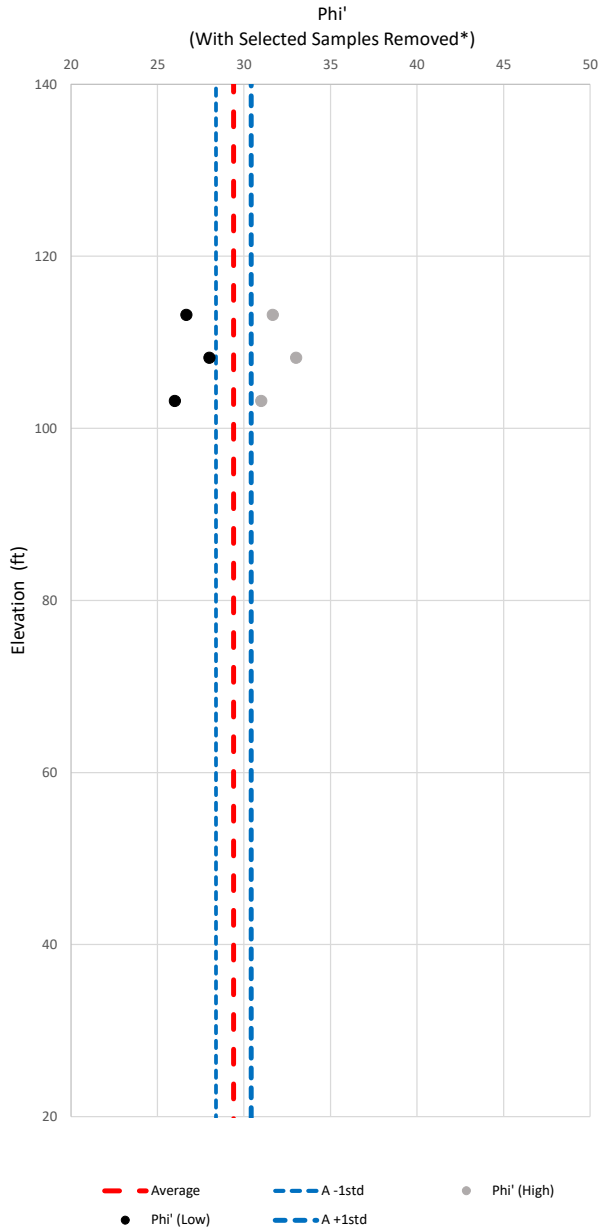
Pick Representative USCS:	CL
Pick Representative Unit Weight:	115
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 0%.

*Using Predominant USCS Classification

ESU 1C - Very Soft to Medium Stiff/Very Loose to Loose Fine-Grained Fill



*See sample table for explanation for removing specified samples if applicable



	ESU Name:	ESU 4B - Dense to Very Dense Sand/Gravel									
		N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	93	145	136	28	-	47	42	130	-	-
	Average:	96	147	137	28	-	47	42	130	-	-
	St. Dev.:	27.6	28.3	23.3	-	-	0.7	0.7	0.0	-	-
	COV:	0.29	0.19	0.17	-	-	0.02	0.02	0.00	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-207-20	98.2												Transition from fill above, underestimate blowcounts
W-207-20	93.2	76	127	121	28	-	46	41	130	-	-	SM	
W-207-20	88.2	115	167	154	28	-	47	42	130	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained shear strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties or using the average of two tested samples

4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 4B - Dense to Very Dense Sand/Gravel

1. Check N160 COV is between 15 and 45%

Selected Design N160:	136
Coefficient of Variation (COV):	0.17

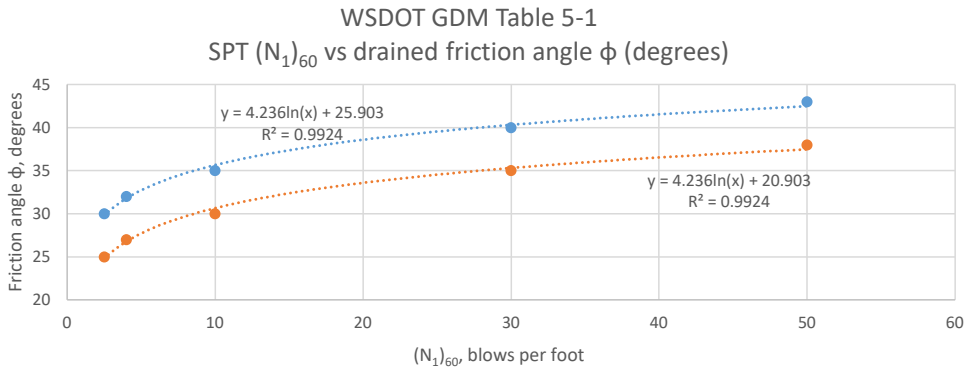
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	47	42	44

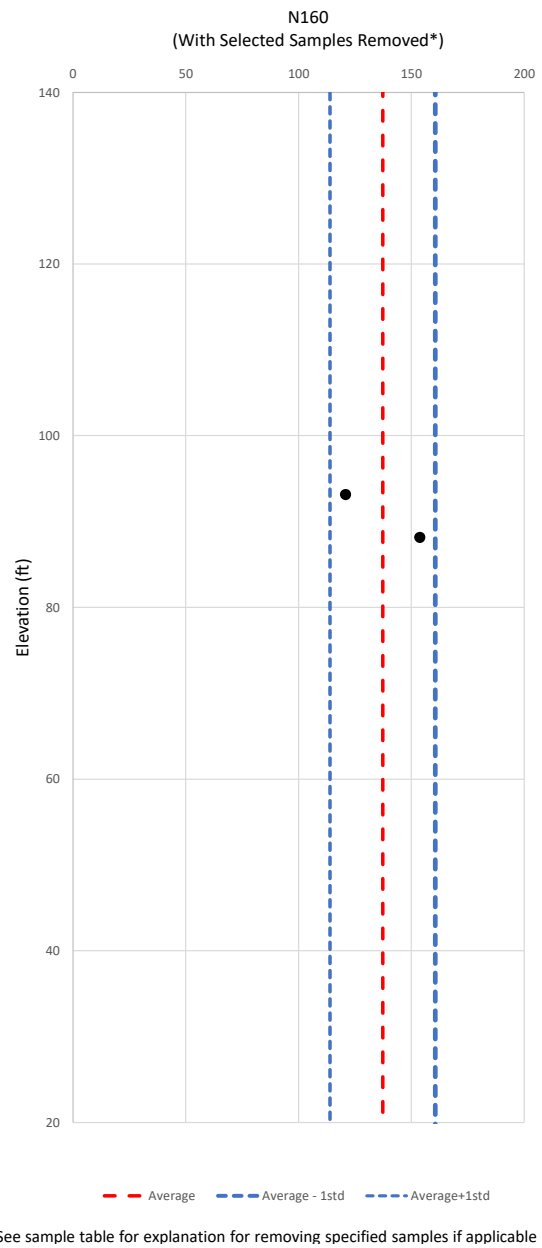
ϕ' COV
0.02

Selected Design Phi' (deg):	43
Notes on Selection:	The estimated geomean fines content is 28% (geomean). The friction angle is taken as the upper bound and capped at 43 degrees for glacially consolidated material with fines content less than 70%.

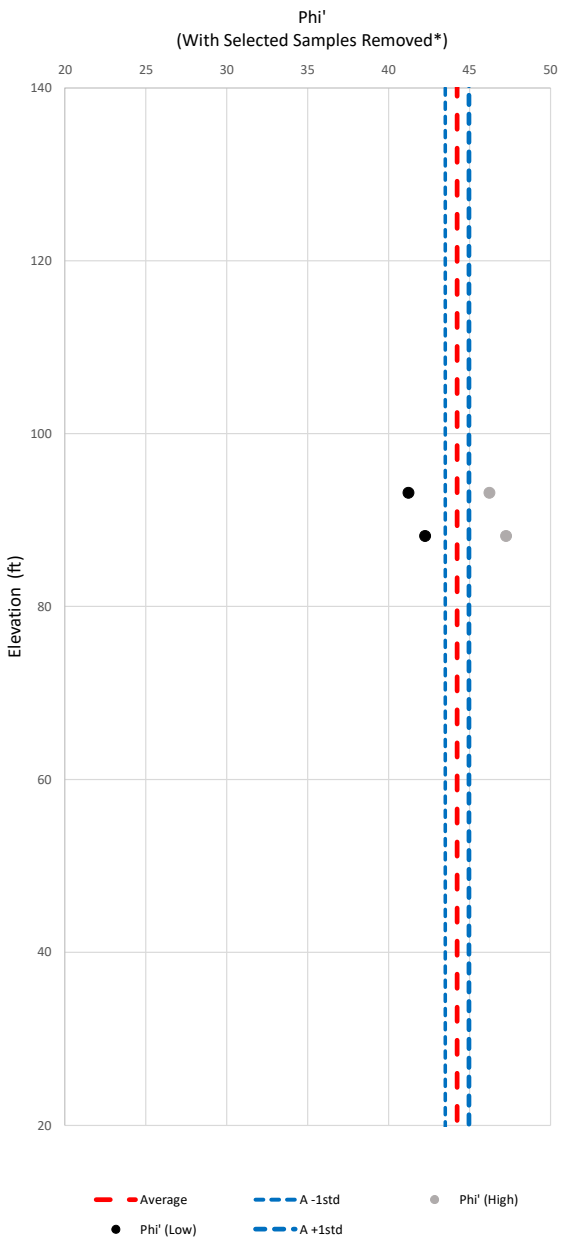
Pick Representative USCS:	SM
Pick Representative Unit Weight:	130
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 0%.

*Using Predominant USCS Classification

ESU 4B - Dense to Very Dense Sand/Gravel



*See sample table for explanation for removing specified samples if applicable



A profile of σ_p', or OCR = σ_p'/σ_o', with depth should be developed for the site for design applications where the stress history could have a significant impact on the design properties selected and the performance of the foundation. As with consolidation properties, an upper and lower bound profile should be developed based on laboratory tests and plotted with a profile based on particular in-situ test(s), if used. It is particularly important to accurately compute preconsolidation stress values for relatively shallow depths where in-situ effective stresses are low. An underestimation of the preconsolidation stress at shallow depths will result in overly conservative estimates of settlement for shallow soil layers.

The coefficient of consolidation, c_v, should be determined from the results of one-dimensional consolidation tests. The variability in laboratory determination of c_v results should be considered in the final selection of the value of c_v to be used for design.

Due to the numerous simplifying assumptions associated with conventional consolidation theory, on which the coefficient of consolidation is based, it is unlikely that even the best estimates of c_v from high-quality laboratory tests will result in predictions of time rate of settlement in the field that are significantly better than a prediction within one order of magnitude. In general, the in-situ value of c_v is larger than the value measured in the laboratory test. Therefore, a rational approach is to select average, upper, and lower bound values for the appropriate stress range of concern for the design application. These values should be compared to values obtained from previous work performed in the same soil deposit. Under the best-case conditions, these values should be compared to values computed from measurements of excess pore pressures or settlement rates during construction of other structures.

CPTu tests in which the pore pressure dissipation rate is measured may be used to estimate the field coefficient of consolidation.

For preliminary analyses or where accurate prediction of settlement is not critical, values obtained from correlations to index properties presented in Sabatini et al. (2002) may be used.

Where evaluation of elastic settlement is critical to the design of the foundation or selection of the foundation type, in-situ methods such as PMT or *DMT* for evaluating the modulus of the stratum should be used.

For preliminary design or for final design where the prediction of deformation is not critical to structure performance, i.e., the structure design can tolerate the potential inaccuracies inherent in the correlations. The elastic properties (E_s, ν) of a soil may be estimated from empirical relationships presented in Table C10.4.6.3-1.

The specific definition of E_s is not always consistent for the various correlations and methods of in-situ measurement. See Sabatini et al. (2002) for additional details regarding the definition and determination of E_s.

An alternative method of evaluating the equivalent elastic modulus using measured shear wave velocities is presented in Sabatini et al. (2002).

Table C10.4.6.3-1—Elastic Constants of Various Soils (modified after U.S. Department of the Navy, 1982; Bowles, 1988)

Soil Type	Typical Range of Young's Modulus Values, E_s (ksi)	Poisson's Ratio, ν (dim)
Clay:		
Soft sensitive		
Medium stiff to stiff	0.347–2.08	0.4–0.5 (undrained)
	2.08–6.94	
Very stiff	6.94–13.89	
Loess	2.08–8.33	0.1–0.3
Silt	0.278–2.78	0.3–0.35
Fine Sand:		
Loose	1.11–1.67	0.25
Medium dense	1.67–2.78	
Dense	2.78–4.17	
Sand:		
Loose	1.39–4.17	0.20–0.36
Medium dense	4.17–6.94	
Dense	6.94–11.11	0.30–0.40
Gravel:		
Loose	4.17–11.11	0.20–0.35
Medium dense	11.11–13.89	
Dense	13.89–27.78	0.30–0.40
Estimating E_s from *SPT N* Value		
Soil Type		E_s (ksi)
Silts, sandy silts, slightly cohesive mixtures		0.056 N_{160}
Clean fine to medium sands and slightly silty sands		0.097 N_{160}
Coarse sands and sands with little gravel		0.139 N_{160}
Sandy gravel and gravels		0.167 N_{160}
Estimating E_s from q_c (static cone resistance)		
Sandy soils		0.028q_c

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Es = 725 ksf = 5.03 ksi
Poisson's Ratio = 0.35

The modulus of elasticity for normally consolidated granular soils tends to increase with depth. An alternative method of defining the soil modulus for granular soils is to assume that it increases linearly with depth starting at zero at the ground surface in accordance with the following equation:

$$E_s = nh \times z \qquad \text{(C10.4.6.3-1)}$$

where:

Appendix C.3 - Grade Separation Barrier 05.33R Design Calculations

AASHTO Average Blowcount in Upper 30'

W-207-20

Depth	Field Blowcount	Energy Corrected Blowcount, N_i	Layer thickness d_i (feet)	Sum(d_i)	d_i/N_i	Sum(d_i/N_i)	N_{ave}
2.5	23	33	3.75	100	0.11	5.8620	**17.1**
5	37	54	2.5		0.05		
7.5	18	26	2.5		0.10		
10	12	17	3.75		0.22		
15	2	3	5		1.72	Driving Energy	87%
20	3	4	5		1.15		
25	2	3	5		1.72		
30	29	42	5		0.12		
35	76	100	5		0.05		
40	115	100	62.5		0.63		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
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					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		

Depth	Field Blowcount	Energy Corrected Blowcount, N_i	Layer thickness di (feet)	Sum(di)	di/Ni	Sum(di/Ni)	Nave
				0	End of Data	0.0	#DIV/0!
					End of Data		
					End of Data		
					End of Data		
					End of Data	Driving Energy	60%
					End of Data		
					End of Data		
					End of Data		
					End of Data		
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					End of Data		
					End of Data		
					End of Data		

Soil Profile Type	v_s (fps)	N
S_A	>5000	N/A
S_B	2,500 to 5,000	
S_C	1,200 to 2,500	>50
S_D	600 to 1,200	15≤N≤50
S_E	<600	<15

Table 20.3-1 Site Classifcation from ASCE Standard 7-10

Name	Nave	Soil Profile Type
W-207-20	17.1	D

Note:

Blowcount Percent (Energy is input BC/60). This spreadsheet approximates the layer thickness based on a function with depth, however, depending on the layering of the log, it may be necessary for the user to input their own layer thicknesses (i.e., clay layer extends at 7.5 ft and the blowcounts need to be weighted to reflect that thickness).

Spreadsheet based on Section 3.10.3.1 of American Association of State Highway and Transportation Officials (AASHTO).

05.33R

BEToolbox™

Spectra

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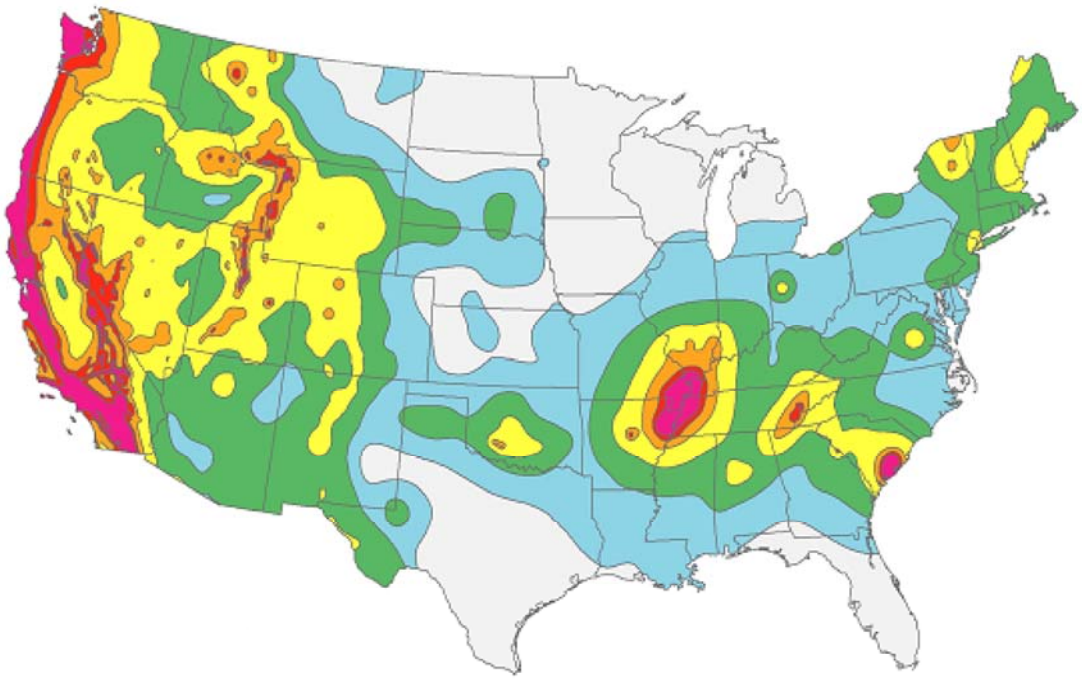
Version 6.0.0.6 BETA - Built on Jan 7 2021



05.33R

WSDOT Bridge Design Manual
2014 Seismic Hazard Map, 7% probability of exceedance in 75 years

Site Coordinates (Latitude,Longitude): 47.5021° N, 122.196° W
Site Soil Classification: Site Class D - Stiff Soil

Seismic hazard maps are for sites at the boundary of Site Classes B and C, which is $\bar{v}_s$ = 2500 ft/s (760 m/s). Adjustments for other Site Classes are made as needed.

Period (sec)	Sa (g)	
0.0	0.432	PGA - Site Class B/C Boundary
0.2	0.985	S_s - Site Class B/C Boundary
1.0	0.282	S_1 - Site Class B/C Boundary

Values of Site Coefficient, F_{pga}, for Peak Ground Acceleration

Site Class	Mapped Peak Ground Acceleration Coefficient (PGA)					
	PGA≤ 0.10	PGA= 0.20	PGA= 0.30	PGA= 0.40	PGA= 0.50	PGA≥ 0.60
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.2	1.2	1.2	1.2	1.2
D	1.6	1.4	1.3	1.2	1.1	1.1
E	2.4	1.9	1.6	1.4	1.2	1.1

For Site Class D, F_{pga} = 1.168

Values for Site Coefficient, F_a, for 0.2 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 0.2 sec (S_s)					
	S_s≤ 0.25	S_s= 0.50	S_s= 0.75	S_s= 1.00	S_s= 1.25	S_s≥ 1.50
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	1.0	0.9	0.9

For Site Class D, F_a = 1.106

Values of Site Coefficient, F_v, for 1.0 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 1.0 sec (S_1)					
	S_1≤ 0.1	S_1= 0.2	S_1= 0.3	S_1= 0.4	S_1= 0.5	S_1≥ 0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2	2.0	1.9	1.8	1.7
E	4.2	3.3	2.8	2.4	2.2	2.0

For Site Class D, F_v = 2.036

$A_s = F_{pga}$ PGA = (1.168)(0.432g) = 0.505g
$S_{DS} = F_a S_s$ = (1.106)(0.985g) = 1.090g
$S_{D1} = F_v S_1$ = (2.036)(0.282g) = 0.575g
$T_o = 0.2T_s$ = (0.2)(0.527) = 0.105 sec
$T_s = S_{D1}/S_{DS}$ = (0.575)/(1.090) = 0.527 sec

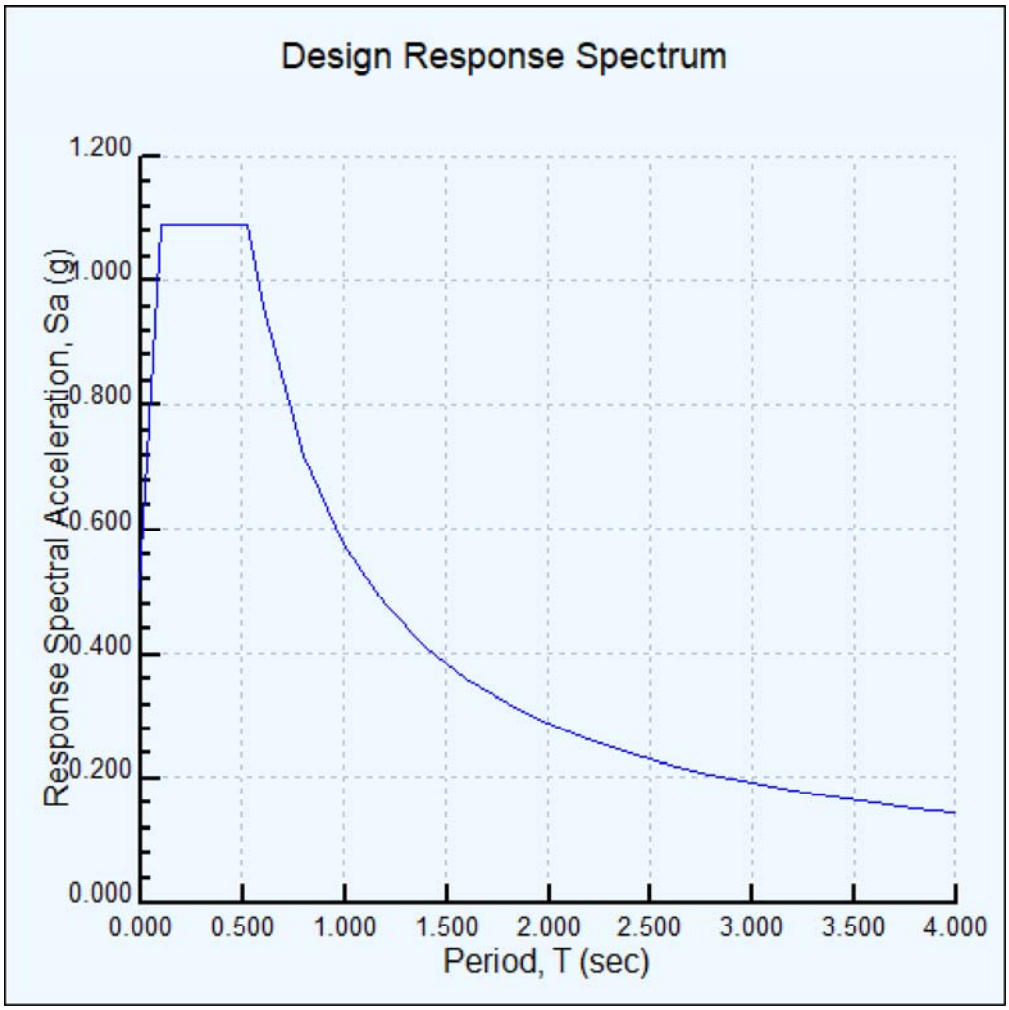
05.33R

Partitions for Seismic Design Categories A, B, C, and D

S_{D1}	SDC
$S_{D1} < 0.15$	A
$0.15 \le S_{D1} < 0.30$	B
$0.30 \le S_{D1} < 0.50$	C
$0.50 \le S_{D1}$	D

Seismic Design Category (SDC) = D

Period, T (sec)	Sa (g)	
0.000	0.505	
0.105	1.090	T_o
0.200	1.090	
0.400	1.090	
0.527	1.090	T_s
0.600	0.958	
0.800	0.718	
1.000	0.575	
1.200	0.479	
1.400	0.410	
1.600	0.359	
1.800	0.319	
2.000	0.287	
2.200	0.261	
2.400	0.239	
2.600	0.221	
2.800	0.205	
3.000	0.192	
3.200	0.180	
3.400	0.169	
3.600	0.160	
3.800	0.151	
4.000	0.144	



General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-00
Boring Designation:	W-207-20
Analysis by:	YTT
Date Analyzed:	2/22/2021
Checked by:	TB
Date Checked:	3/9/2021

Sampling Information	
Depth to Groundwater (ft):	10.9
SPT Liner (Yes/No):	No
Hammer Energy, %:	87
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	8

GW estimated from H-3-65 ATD

Earthquake Information	
Max Acceleration (g) :	0.505
Earthquake Magnitude:	7.0

Site Class D SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

Collect Data From gINT

Automate %F from USCS

Auto %F from WSDOT GDM

COMPUTE

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	2.5	23	SM	37	ESU 1B	130		Unsaturated	
	5	37	SM	37	ESU 1B	130		Unsaturated	
	7.5	18	SM	34	ESU 1B	120		Unsaturated	
	10	12	SM	31	ESU 1B	115			
	15	2	CL	50	ESU 1C	115		Cohesive	
	20	3	CL	50	ESU 1C	115		Cohesive	
	25	2	CL	50	ESU 1C	115		Cohesive	
	30	29	SM	28	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	35.0	76	SM	28	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	40.0	115	SM	28	ESU 4B	130		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	2.5	23	SM	37	47	47	2.00	2.00	0.0	0.0	0.1	0.0	47.1	48.9	46.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	5.0	37	SM	37	72	67	2.00	2.00	0.0	0.0	0.1	0.0	67.3	83.9	68.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.5	18	SM	34	32	31	2.00	2.00	0.0	0.0	0.1	0.0	31.0	35.8	30.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	10.0	12	SM	31	21	21	1.57	1.27	0.0	0.0	0.1	0.0	21.0	22.2	19.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	15.0	2	CL	50	4	4	2.00	2.00	0.0	0.0	0.0	0.0	3.7	3.7	3.4	122	90	119	123	114	175
	20.0	3	CL	50	5	5	2.00	2.00	0.0	0.0	0.0	0.0	5.1	5.1	4.9	158	125	155	165	145	219
	25.0	2	CL	50	3	3	2.00	2.00	0.0	0.0	0.0	0.0	3.2	3.2	3.1	135	112	151	155	126	160
	30.0	29	SM	28	45	47	2.00	2.00	0.0	0.0	0.0	0.0	46.7	45.2	45.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	35.0	76	SM	28	111	118	2.00	2.00	0.0	0.0	0.0	0.0	118.2	111.0	113.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	40.0	115	SM	28	138	151	2.00	2.00	0.0	0.0	0.0	0.0	173.5	158.5	164.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

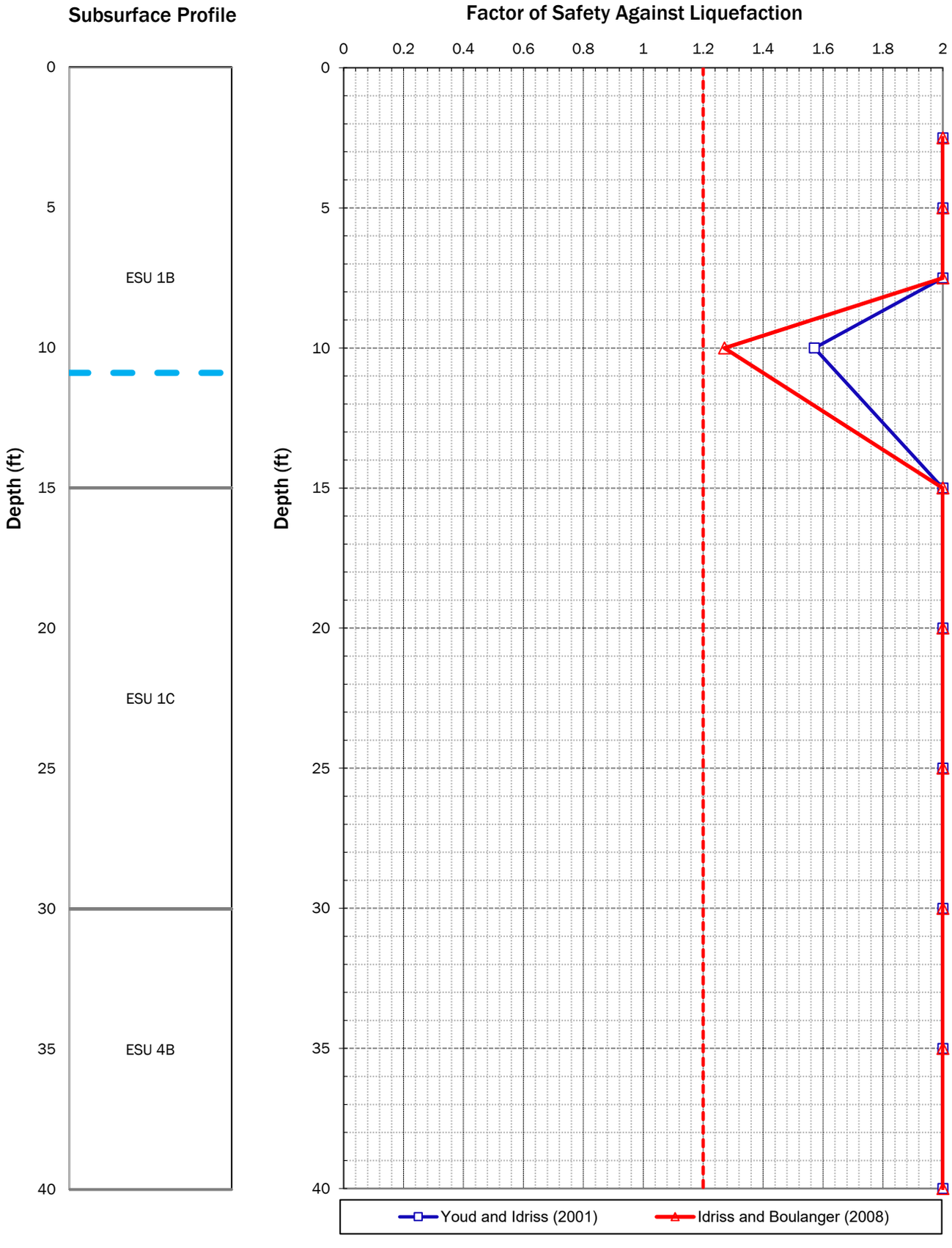
Seismic Parameters	
Max Acceleration (g) :	0.505
Earthquake Magnitude:	7.00

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, W-207-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

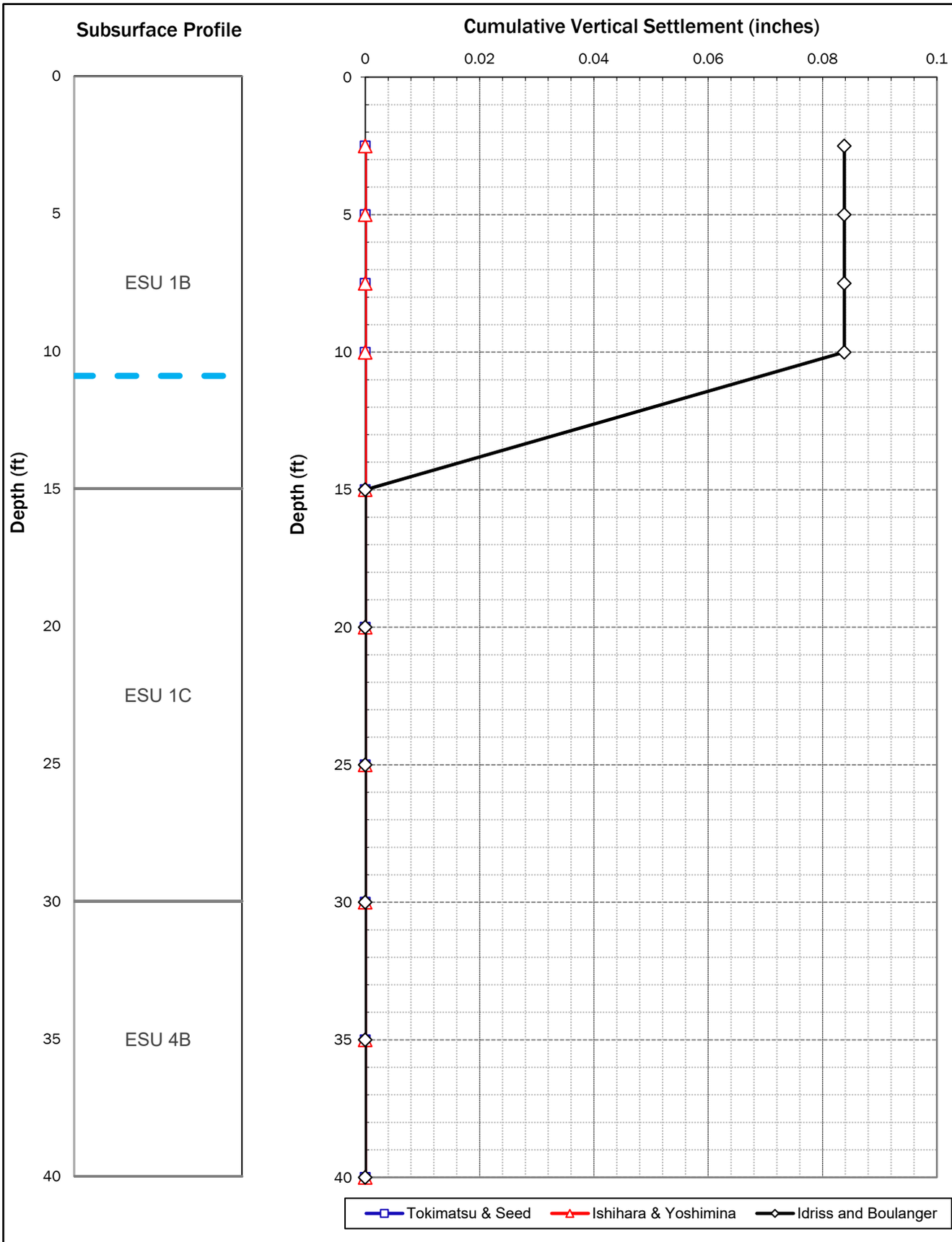


Factor of Safety Against Liquefaction, W-207-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-00; Date Checked: 3/9/2021



Cumulative Liquefaction-Induced Settlement, W-207-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-00; Date Checked: 3/9/2021

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	I-405/Renton to Bellevue Corridor Widening
Owner:	WSDOT
Job Number:	00180-366-01
Analysis by:	YTT
Date/Time:	1/18/2022 9:30 AM
Checked by:	TB

Input Parameters

Material	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
Common Borrow	32	0	17.5	0	0	10.8	120	57.6	1	0.253	0
Select Borrow	36	0	17.5	0	0	10.8	125	62.6	1	0.253	0
Gravel Borrow	38	0	17.5	0	0	10.8	130	67.6	1	0.253	0

Lateral Earth Pressures

Output

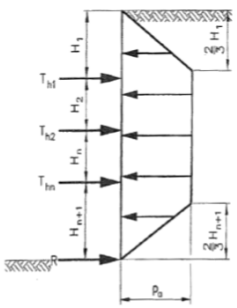
Material	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic				Seismic Pressure - Rectangular
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], X	K_{ae}	γ_{ae} (pcf)	γ'_{ae} (pcf)	K_{pe}	(psf * H)
Common Borrow	0.49	58.74	28.19	2.68	321.39	154.27	571.32	274.23	0.47	56.41	27.08	58.74	58.74	1.04	125.11	60.05	4.76	33.19
Select Borrow	0.42	52.25	26.17	3.07	383.26	191.94	801.00	401.14	0.41	51.53	25.80	52.25	52.25	0.76	95.22	47.68	6.41	21.48
Gravel Borrow	0.39	50.18	26.09	3.29	427.31	222.20	978.48	508.81	0.38	49.96	25.98	50.18	50.18	0.69	89.66	46.62	7.53	19.74

Notes:

[1] "X" to be used in the following equation:

$$\frac{X \cdot H^2}{1.5H - 0.5H_1 - 0.5H_{n+1}}$$

where H_1 and H_{n+1} are represented by this diagram:



Recommended Lateral Earth Pressures

Soil Type	φ'	Sliding Friction Coefficient	
		Cast-In-Place Concrete	Precast Concrete
Common Borrow	32	0.62	0.50
Select Borrow	36	0.73	0.58
Gravel Borrow	38	0.78	0.63
ESU 1B	36	0.73	0.58

Notes:
Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2

Cast-In-Place Concrete Coefficient of Friction:
Coefficient of friction = 1.0*tan(Phi')

Precast Concrete Coefficient of Friction:
Coefficient of friction = 0.8*tan(Phi')

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for concrete cast against soil
= 0.8 for precast concrete footing

where:

ϕ_f = internal friction angle of drained soil (degrees)
V = total vertical force (kips)

LRFD Foundation Design

Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications

Date/Time:	1/11/22 10:24 AM
Project Name:	**I-405/Renton to Bellevue Corridor Widening**
Project No.:	**00180-366-01**

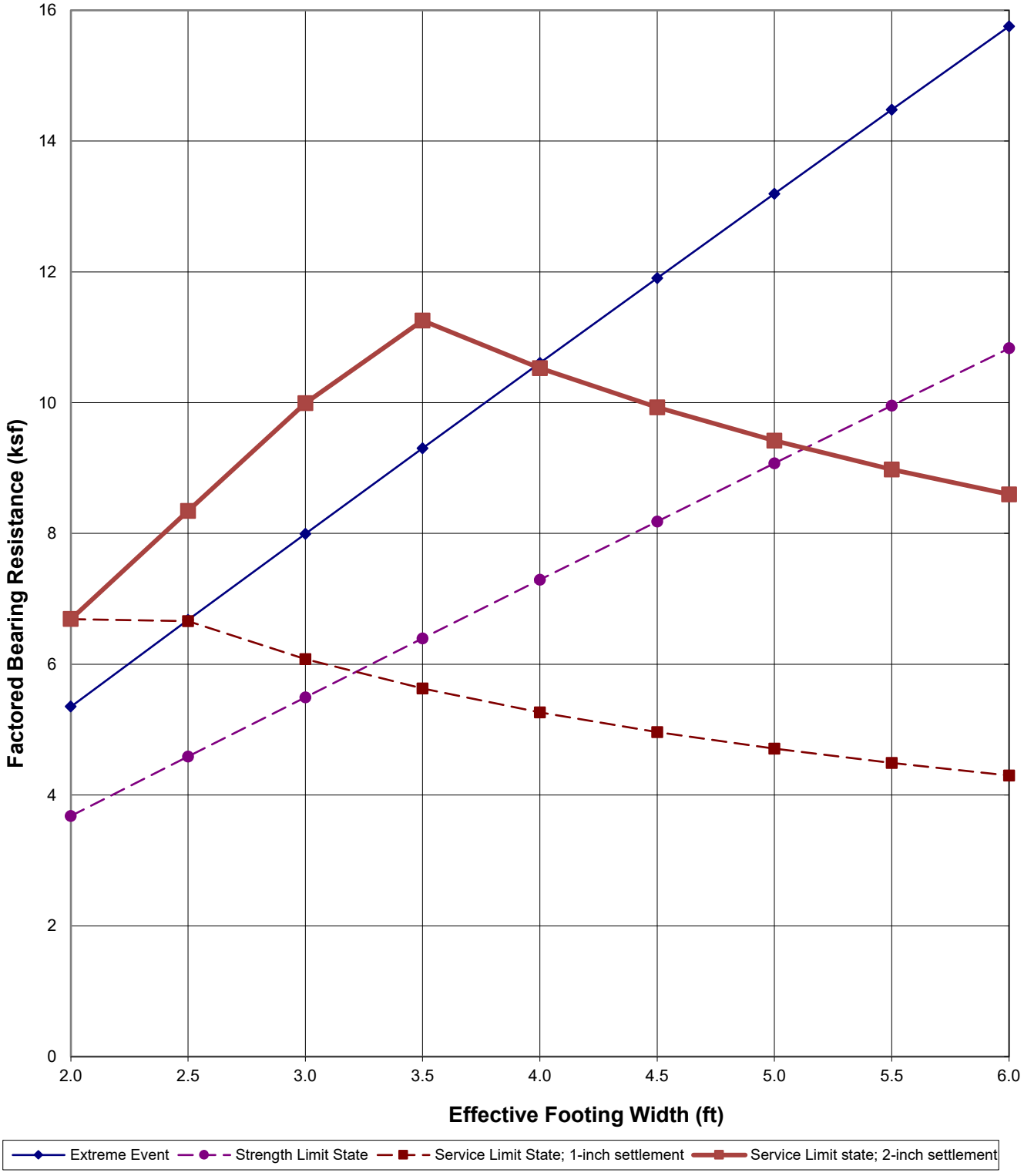
Foundation Soil Conditions		
Unit Weight, γ (pcf)	**120**	(ESU 1B, Dense SM)
Friction angle, Φ (degrees)	**36**	
Friction angle, Φ (rad)	0.628	
Cohesion, C (psf)	**0**	
Embedment, D_f (ft)	**0**	
Depth to Groundwater, D_w (ft)	**10.9**	
Footing Length, L (ft)	**85**	(approx wall length)
Footing Width, B (ft)	**1**	
Poissons Ration, ν	0.35	
Young's Modulus, E_s (ksf)	**725**	

Bearing Capacity Factors	
N_γ	56
N_c	51
N_q	38

Effective Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.8) for gravity and semigravity walls (Section 11.5.8 AASHTO)	**Working Bearing Resistance** Resistance Factor (0.55) for gravity and semigravity walls (Table 11.5.7-1)	Deflection from Elastic Settlement Spreadsheet **1" Deflection**	Deflection from Elastic Settlement Spreadsheet **2" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
2.0	1.0	1.0	1.02	0.99	1.02	6.7	5.4	3.7	6.7	6.7
2.5	1.0	1.0	1.02	0.99	1.02	8.3	6.7	4.6	6.7	8.3
3.0	1.0	1.0	1.03	0.99	1.03	10.0	8.0	5.5	6.1	10.0
3.5	1.0	1.0	1.03	0.98	1.03	11.6	9.3	6.4	5.6	11.3
4.0	1.0	1.0	1.04	0.98	1.03	13.3	10.6	7.3	5.3	10.5
4.5	1.0	1.0	1.04	0.98	1.04	14.9	11.9	8.2	5.0	9.9
5.0	1.0	1.0	1.04	0.98	1.04	16.5	13.2	9.1	4.7	9.4
5.5	1.0	1.0	1.05	0.97	1.05	18.1	14.5	10.0	4.5	9.0
6.0	1.0	1.0	1.05	0.97	1.05	19.7	15.8	10.8	4.3	8.6

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing are to be excavated.

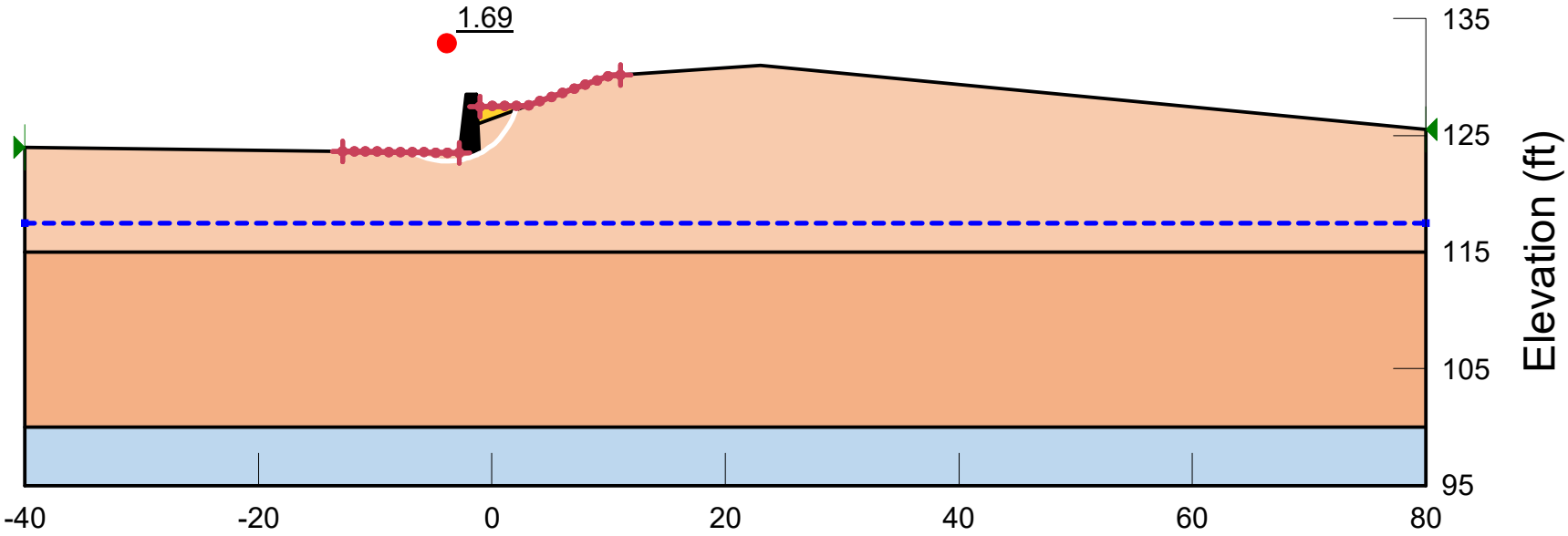
Wall 05.33R Bearing Resistance



GeoEngineers
Earth Science + Technology

Shallow Foundation Design

Color	Name	Model	Unit Weight	Cohesion'	Phi'
	1B Med. Dense to V. Dense Coarse-Grained Fill	Mohr-Coulomb	120	0	36
	1C V. Soft to Med. Stiff/V. Loose to Loose Fine-Grained Fill	Mohr-Coulomb	115	0	27
	4B Dense to V. Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	Barrier	High Strength	150		
	Common Borrow	Mohr-Coulomb	120	0	32



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master files is stored by GeoEngineers, Inc. and will serve as the official record of this communication

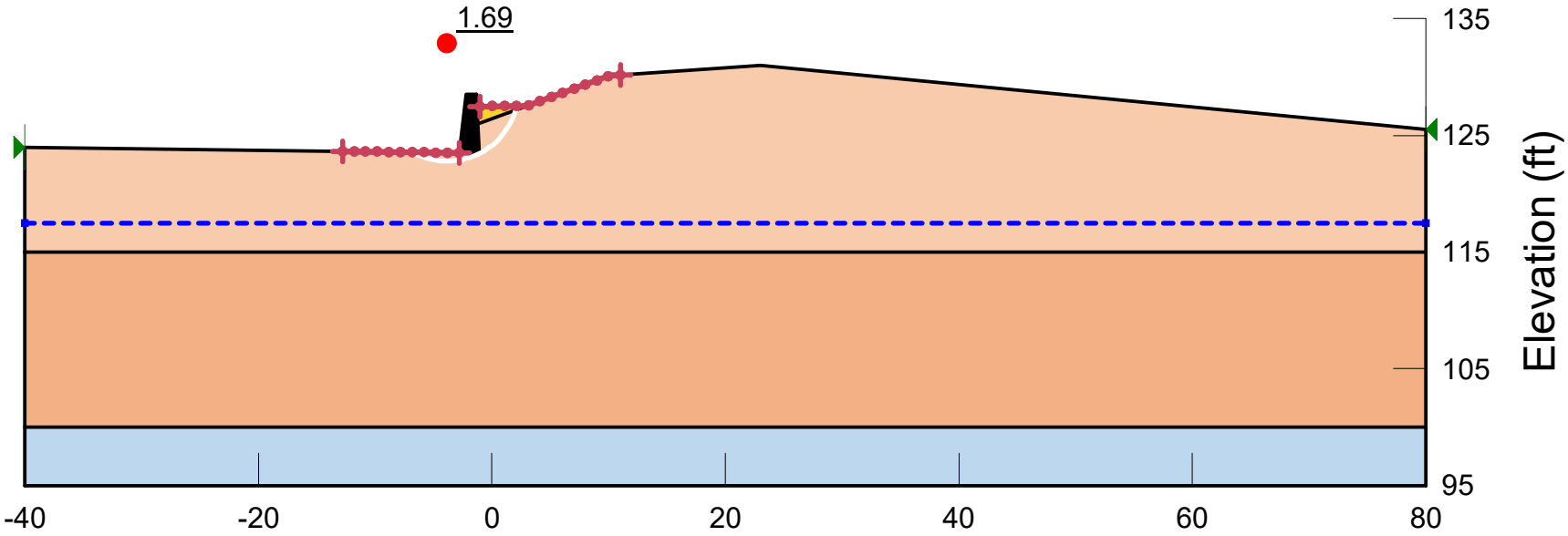
Grade Separation Barrier 05.33R - Sta. 1+58
Static Global Stability (Spencer)

I-405/ Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

000180-366-01 Date Exported: 08/06/21

Color	Name	Model	Unit Weight	Cohesion'	Phi'
	1B Med. Dense to V. Dense Coarse-Grained Fill	Mohr-Coulomb	120	0	36
	1C V. Soft to Med. Stiff/V. Loose to Loose Fine-Grained Fill	Mohr-Coulomb	115	0	27
	4B Dense to V. Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	Barrier	High Strength	150		
	Common Borrow	Mohr-Coulomb	120	0	32



Notes:

1. The locations of all features shown are approximate.
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Grade Separation Barrier 05.33R - Sta. 1+58
Static Global Stability (M-P)

I-405/ Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

000180-366-01 Date Exported: 08/06/21

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Appendix D
Wall 05.55L Calculations

APPENDIX D - WALL 05.55L CALCULATIONS

General

This appendix presents geotechnical calculations for Wall 05.55L including:

- ESU Soil Properties
- Seismic Hazard Analysis
- Lateral Earth Pressures
- Coefficients of Friction for Sliding
- Bearing Resistance and Elastic Settlement
- Global Stability

ESU Soil Properties

Design soil properties were developed in accordance with the Project GDM, AASHTO LRFD, and FHWA. We calculated the average, geometric mean, and standard deviation within each ESU. We verified the reliability of the ESU data set by comparing the COV of each calculated geometric mean value to measured and interpreted values presented in Sabatini et al. (2002) Table 52.

A detailed description of the soil property development is presented in Section 7.1 of this geotechnical engineering report. Supporting calculations are provided in this appendix.

Seismic Hazard Analysis

We selected a representative site class for the wall from the site class evaluation of nearby borings. We evaluated the site class of each boring using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 3.10.3.1.

We developed seismic design parameters using the WSDOT Bridge Engineering Software BEToolbox/BridgeLink in accordance with the WSDOT BDM based on the projected ground motion at the project site that has a 7 percent (SEE) probability of exceedance in a 75-year period (approximate 1,000-year return period).

We used a mean earthquake magnitude at the PGA period is 7.0 for the SEE based on the Hart Crowser seismic design report "I-405 R2B Segment 1a Site-Specific Hazard Analysis RFU," dated March 25, 2021.

The soil samples at Wall 05.55L are unsaturated and calculated $N1_{60}$ values are greater than 25 blows per foot. By inspection, liquefaction potential is low. We confirmed our low liquefaction risk assumptions by evaluating liquefaction potential using a spreadsheet developed by GeoEngineers in accordance with Project GDM Chapter 6. The FSs against liquefaction at Wall 05.55L were greater than 1.2 for all soil analyzed; per Project GDM Section 6-4.2.3, soils with liquefaction potential are defined as those with FSs against liquefaction less than 1.2.

Detailed descriptions of our seismic hazard analysis methodology and the results are presented in Section 7.2 and Section 8.1, respectively, of this report. Site class calculations, WSDOT BDM software outputs, and liquefaction analyses are provided in this appendix.

Lateral Earth Pressures

Active lateral pressure coefficients and active lateral earth pressures for imported common borrow, select borrow, and gravel borrow were calculated in accordance with AASHTO LRFD Sections 3.11.5 and 11.6.5.3 using the proposed horizontal backslope behind the wall, and the 3.7H:1V foreslope in front of the wall. Lateral earth pressures shall be applied using a triangular distribution. An LRFD load factor of 1.5 shall be applied to the active earth pressures in accordance with AASHTO LRFD Table 3.4.1-2. Due to negligible embedment of the wall and a foreslope condition, passive lateral earth pressures shall be ignored.

Surcharge loads, such as traffic loading, and appropriate load factors shall be applied to evaluate the wall stability. All surcharges shall apply load factors in accordance with AASHTO LRFD Tables 3.4.1-1 and 3.4.1-2.

A detailed description of our analysis methodology and the calculated results are presented in Section 7.3 and Section 8.2, respectively. Supporting calculations are provided in this appendix.

Coefficients of Friction for Sliding

Coefficients of friction for sliding on surficial native soils, common borrow, select borrow, and gravel borrow were calculated using AASHTO LRFD equation 10.6.3.4-2.

A detailed description of our analysis methodology and the results are presented in Section 7.4 and Section 8.3, respectively, of this report. Supporting calculations are provided in this appendix.

Bearing Resistance and Elastic Settlement

We estimated the bearing resistance and elastic settlement of the wall using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 10.6.3. We estimated elastic settlement from procedures outlined in AASHTO LRFD and Section 10.6.2.4. Sliding and overturning are being evaluated by the design-build team's wall designers and will be submitted under separate cover.

A detailed description of our analysis methodology and the results are presented in Section 7.5 and Section 8.4, respectively, of this report. Supporting calculations are provided in this appendix.

Global Stability

We performed global stability analyses for the following critical design section:

- Section Sta. 1+50 – Maximum overall wall height

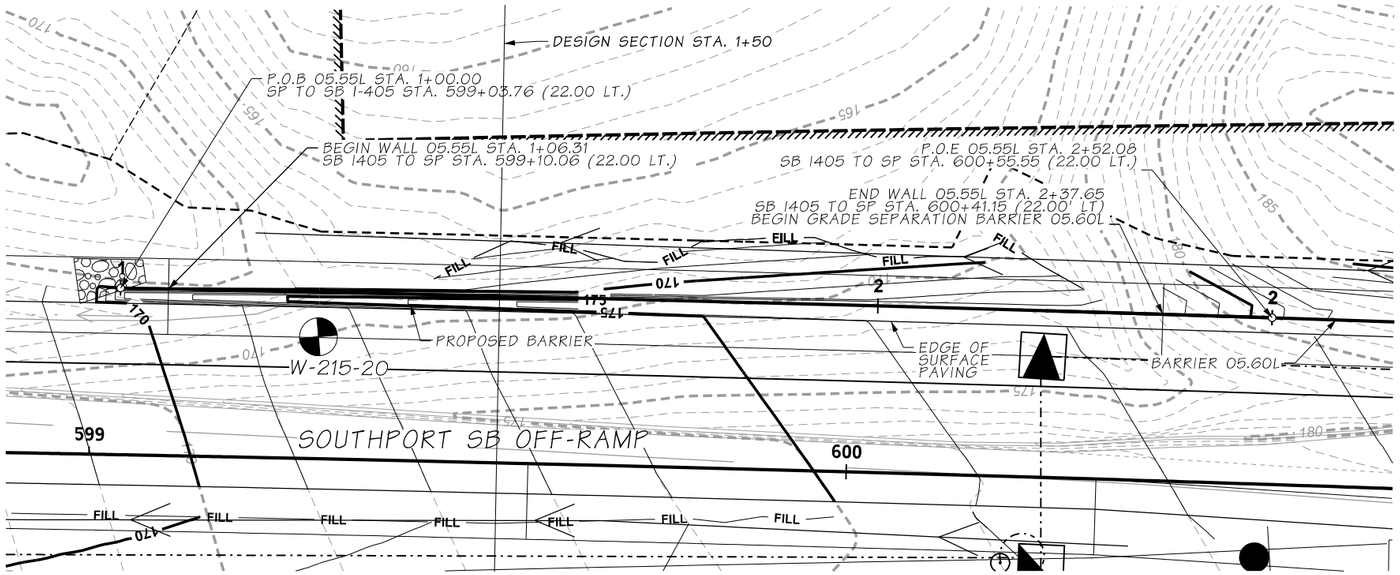
Global stability was evaluated using limit equilibrium analysis methodology outlined in the Project GDM using the computer design software Slope/W (Geo Slope International, Ltd. 2020). We analyzed FSs using Spencer's method and Morgenstern-Price for a circular failure surface.

A traffic surcharge of 250 psf was applied at the top of the wall for the static global stability analysis.

Based on criteria outlined in the Hart Crowser RFU geotechnical letter "Design Requirements and Geotechnical Assessment of Retaining Walls" dated January 26, 2021, the MADTL for Wall 05.55L is less than the distance between the wall and the travel lane, and therefore additional improvements are not required since seismic failure of the wall will not severely impact the traveled way or compromise the life safety of the public. Accordingly, we did not analyze seismic stability of Wall 05.55L.

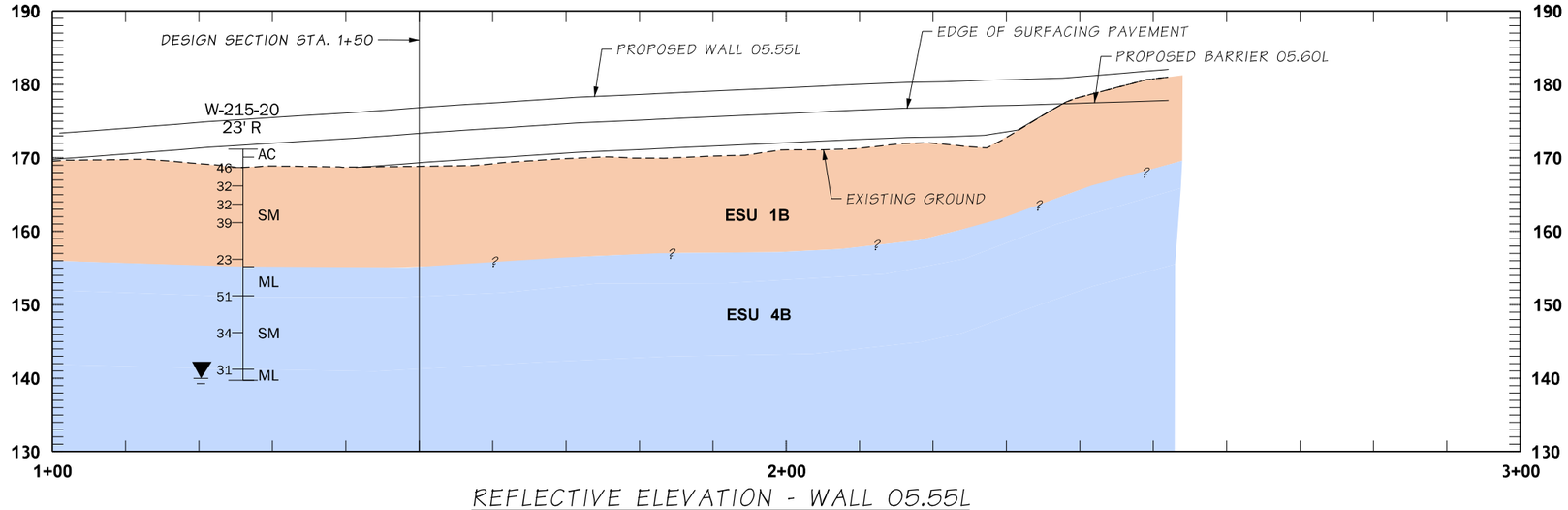
Detailed descriptions of our global stability analysis methodology and the results of our analyses are presented in Section 7.8 and Section 8.6, respectively, of this report. Global stability models showing FS for critical failures at the design section are provided in this appendix. Slope/W reports are provided in Appendix J.

Appendix D.1 - Wall 05.55L Plan, Profile and Sections



PLAN - WALL 05.55L

0 10 20
SCALE IN FEET



REFLECTIVE ELEVATION - WALL 05.55L

DATUM
(NAVD) 88

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN AND ELEVATION WALL 05.55L

PLAN REF NO

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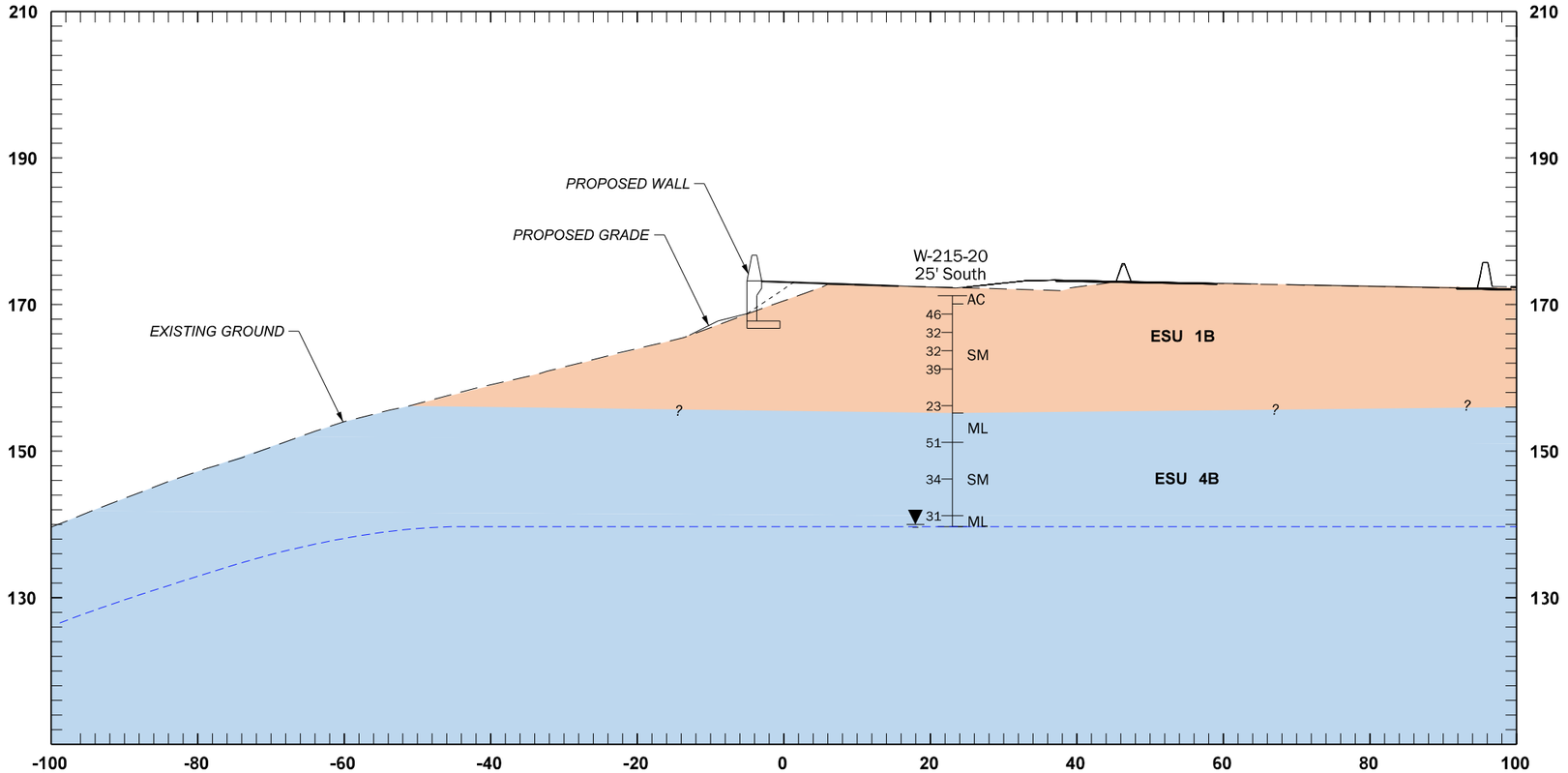

WALL 05.55L STATION 1+50

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

WALL 05.55L
DESIGN SECTION AT STA. 1+50

PLAN REF NO

SHEET 1 OF 1 SHEETS

Appendix D.2 - Wall 05.55L
ESU Soil Property Calculations

05.55L

Soil Properties Summary

ESU	Description	Total No. of Samples [b]	USCS [c]	Fines [d] (%)	Plasticity Index, PI [e] (%)	Raw N (bpf)	N_{60} [f] (bpf)		$(N_1)_{60}$ [f] (bpf)		Total Unit Weight [g] (pcf)		Effective Friction Angle, ϕ' [h] (deg)		Fully Softened ϕ' [i] (deg)	Effective c' [j] (psf)	Residual ϕ' [k] (deg)	Residual Shear Strength, Sr (psf)	Undrained Shear Strength, Su (psf)	
				Value	Value	Value	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	Value	Value	Value	Value	COV
1B	Medium Dense to Very Dense Coarse-Grained Fill	4	SM	26	-	37	49	16%	66	27%	130	0%	40	3%	-	-	-	-	-	-
4B	Dense to Very Dense Sand/Gravel	4	SM	40	-	33	54	33%	51	33%	120	10%	43	3%	-	-	-	-	-	-

Notes:

a. Coefficient of Variation (COV) percentage calculated to verify the variability and reliability of sample data within ESU (WSDOT GDM Section 5.11.2 (2015)). Calculated COV percentage compared to ranges presented in Table 52 (Sabatini et al. 2002) (below).

b. Number of samples excludes outliers.

c. Predominant USCS classification of all samples in ESU. Sandstone, where encountered, denoted as (SS).

d. Fines content percentage calculated as the geometric mean of all samples, whose values were determined through lab testing or estimated from field classification.

e. For coarse-grained ESUs, the plasticity index was estimated from the fine-grained portion of the soil. For fine-grained ESUs, if lab data is limited, the plasticity index may not be representative of the overall soil unit.

f. Corrected blow counts (N_{60} and $(N_1)_{60}$) were calculated following WSDOT GDM Section 5.5 (2015).

g. Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Unit weight data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.

h. Design friction angles were selected by considering fines content. Friction angle data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.

i. Where applicable, fully softened friction angle was estimated following WSDOT GDM, Figure 5-7 (After Stark and Hussain, 2013).

j. Where applicable, effective cohesion was calculated using Equations 6 through 8 in the WOOD Geotechnical SPM.

k. Where applicable, residual friction angle (to be used for slope stability evaluation) was estimated following WSDOT GDM, Figure 5-5 (After NAVFAC, 1971).

Measured or interpreted parameter value	Coefficient of Variation, V (%)
Unit weight, γ	3 to 7 %
Buoyant unit weight, γ_b	0 to 10 %
Effective stress friction angle, ϕ'	2 to 13 %
Undrained shear strength, s_u	13 to 40 %
Undrained strength ratio (s_u/σ_v')	5 to 15 %
Compression index, C_c	10 to 37 %
Preconsolidation stress, σ_p'	10 to 35 %
Hydraulic conductivity of saturated clay, k	68 to 90 %
Hydraulic conductivity of partly-saturated clay, k	130 to 240 %
Coefficient of consolidation, c_v	33 to 68 %
Standard penetration blowcount, N	15 to 45 %
Electric cone penetration test, q_c	5 to 15 %
Mechanical cone penetration test, q_c	15 to 37 %
Vane shear test undrained strength, s_{uVST}	10 to 20 %

Source: Table 52 (Sabatini et al. 2002)

	ESU Name:	ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill									
		N	N_{60}	$(N_1)_{60}$	%F	PI [3] (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	37	49	66	26	-	44	39	130	-	-
	Average:	37	50	67	26	-	44	39	130	-	-
	St. Dev.:	6.7	8.0	18.3	-	-	1.1	1.1	0.0	-	-
	COV:	0.18	0.16	0.27	-	-	0.02	0.03	0.00	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [4]	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [5] (psf)	USCS	Explanation for Sample Removal
W-215-20	168.7	46	58	94	30	-	45	40	130	-	-	SM	
W-215-20	166.2	32	43	59	27	-	43	38	130	-	-	SM	
W-215-20	163.7	32	43	53	23	-	43	38	130	-	-	SM	
W-215-20	161.2	39	55	64	23	-	43	38	130	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained shear strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties or using the average of two tested samples
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill

1. Check N160 COV is between 15 and 45%

Selected Design N160:	66
Coefficient of Variation (COV):	0.27

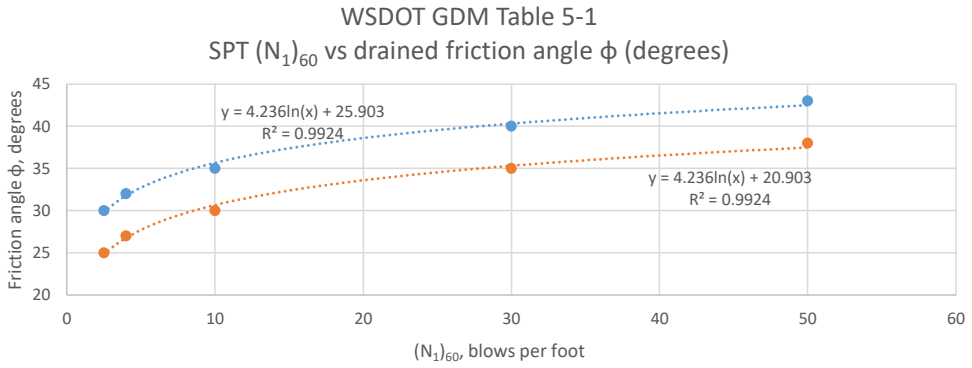
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



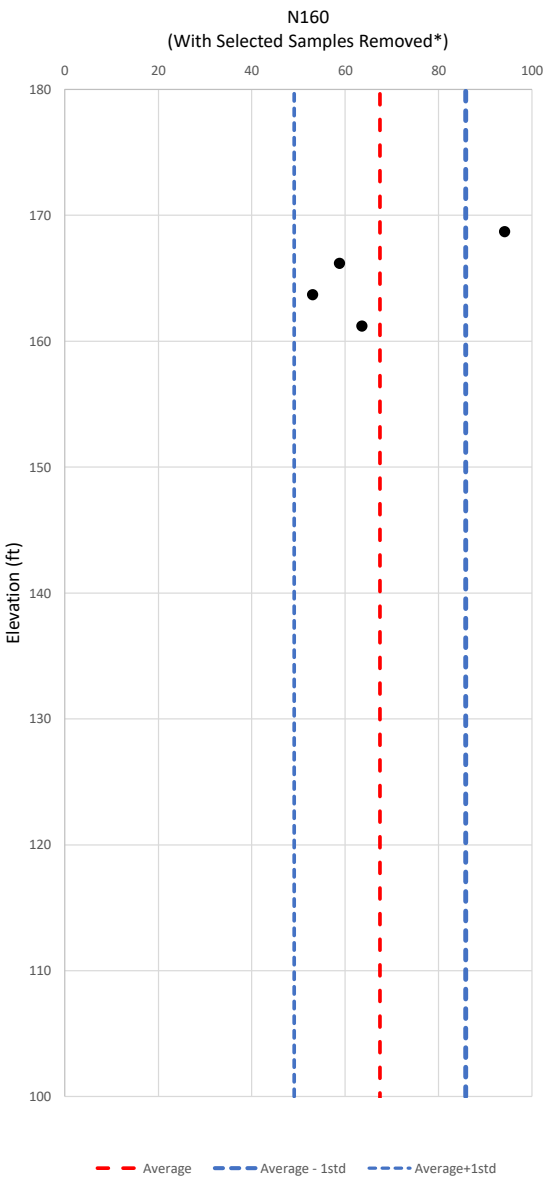
	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	44	39	41

ϕ' COV
0.03

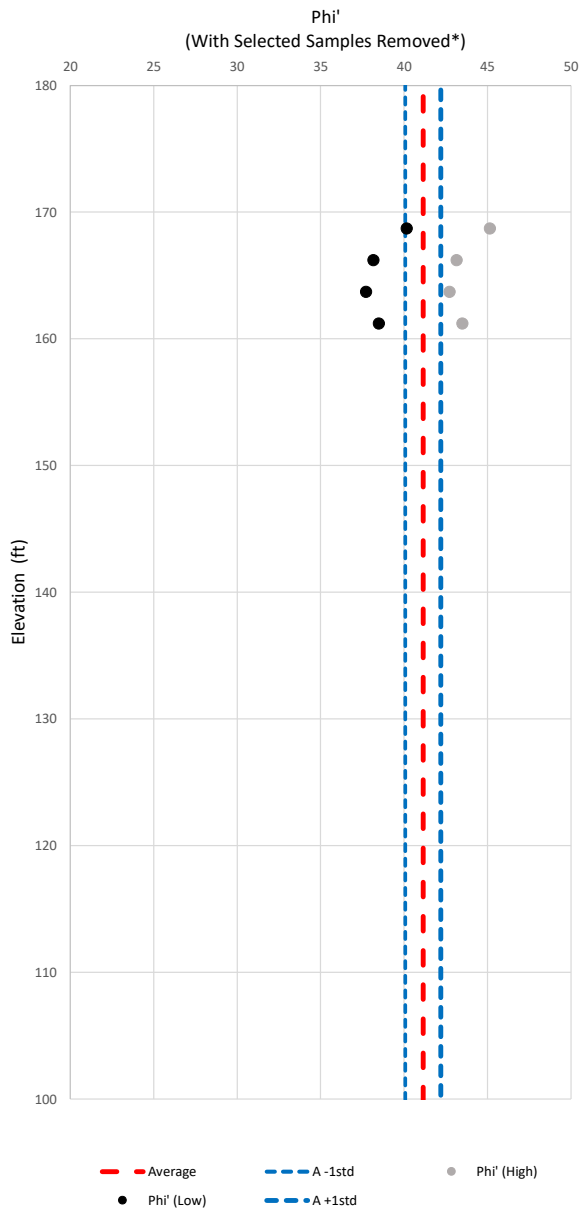
Selected Design Phi' (deg):	40
Notes on Selection:	The fines content test data is representative of the ESU. The estimated fines content is 26% (geomean). The friction angle is interpolated based on fines content (phi' (high) at 5% fines, and phi' (low) at 30% fines).

Pick Representative USCS:	SM	*Using Predominant USCS Classification
Pick Representative Unit Weight:	130	
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 0%.	

ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill



*See sample table for explanation for removing specified samples if applicable



ESU Name:	ESU 4B - Dense to Very Dense Sand/Gravel									
	N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
GeoMean:	33	54	51	40	-	43	38	120	-	-
Average:	35	56	52	47	-	43	38	120	-	-
St. Dev.:	11.8	18.4	17.5	-	-	1.3	1.3	11.5	-	-
COV:	0.34	0.33	0.33	-	-	0.03	0.03	0.10	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	Φ' (high) (deg)	Φ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-215-20	156.2	23	36	38	72	-	41	36	110	-	-	ML	
W-215-20	151.2	51	81	78	23	-	44	39	130	-	-	SM	
W-215-20	146.2	34	54	49	23	-	42	37	130	-	-	SM	
W-215-20	141.2	31	52	45	70	-	42	37	110	-	-	ML	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained shear strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties or using the average of two tested samples
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 4B - Dense to Very Dense Sand/Gravel

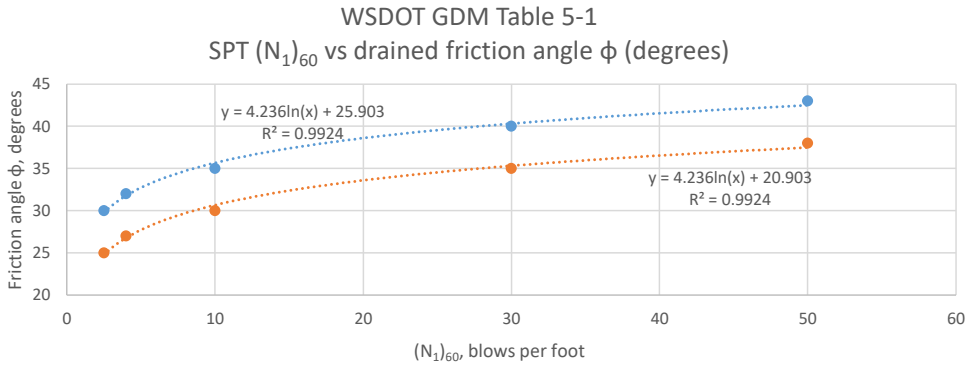
1. Check N160 COV is between 15 and 45%

Selected Design N160:	51
Coefficient of Variation (COV):	0.33

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43



* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)

	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	43	38	40

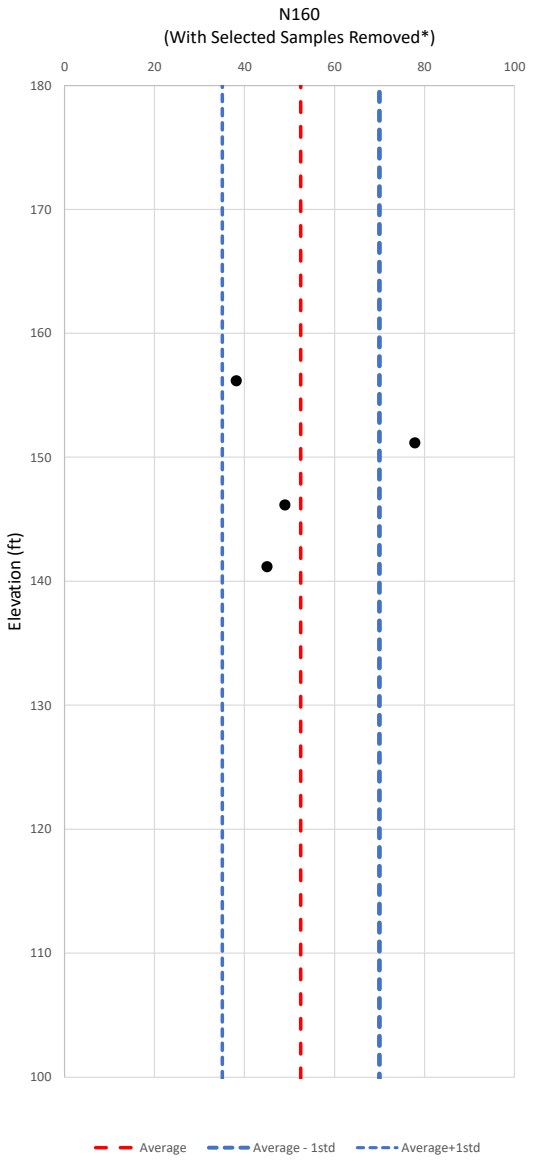
ϕ' COV
0.03

Selected Design Phi' (deg):	43
Notes on Selection:	The estimated geomean fines content is 40% (geomean). The friction angle is taken as the upper bound and capped at 43 degrees for glacially consolidated material with fines content less than 70%.

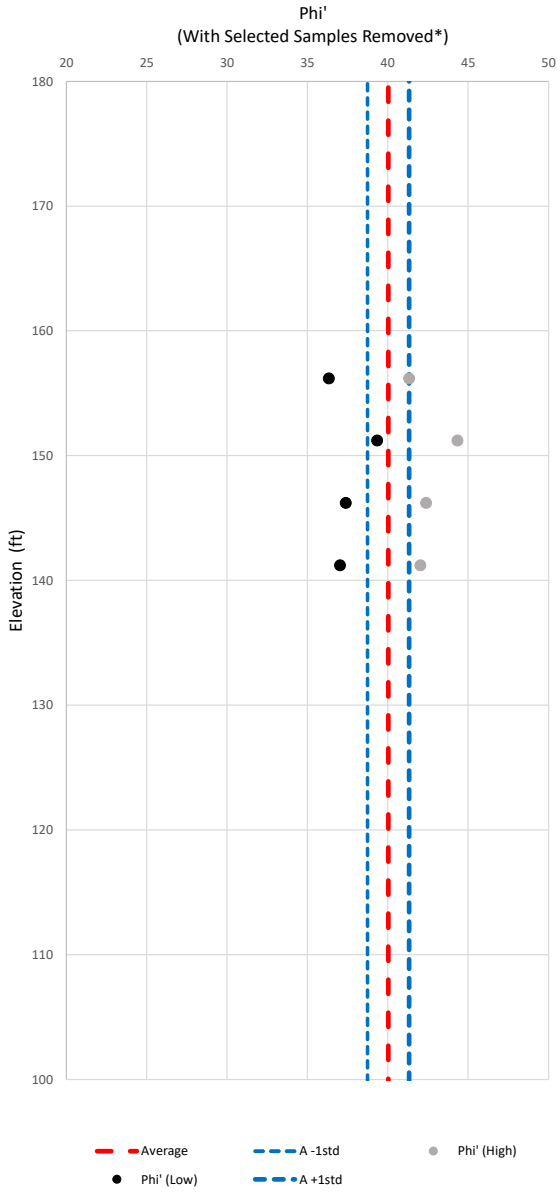
Pick Representative USCS:	SM
Pick Representative Unit Weight:	120
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 10%.

*Using Predominant USCS Classification

ESU 4B - Dense to Very Dense Sand/Gravel



*See sample table for explanation for removing specified samples if applicable



A profile of σ_p', or OCR = σ_p'/σ_o', with depth should be developed for the site for design applications where the stress history could have a significant impact on the design properties selected and the performance of the foundation. As with consolidation properties, an upper and lower bound profile should be developed based on laboratory tests and plotted with a profile based on particular in-situ test(s), if used. It is particularly important to accurately compute preconsolidation stress values for relatively shallow depths where in-situ effective stresses are low. An underestimation of the preconsolidation stress at shallow depths will result in overly conservative estimates of settlement for shallow soil layers.

The coefficient of consolidation, c_v, should be determined from the results of one-dimensional consolidation tests. The variability in laboratory determination of c_v results should be considered in the final selection of the value of c_v to be used for design.

Due to the numerous simplifying assumptions associated with conventional consolidation theory, on which the coefficient of consolidation is based, it is unlikely that even the best estimates of c_v from high-quality laboratory tests will result in predictions of time rate of settlement in the field that are significantly better than a prediction within one order of magnitude. In general, the in-situ value of c_v is larger than the value measured in the laboratory test. Therefore, a rational approach is to select average, upper, and lower bound values for the appropriate stress range of concern for the design application. These values should be compared to values obtained from previous work performed in the same soil deposit. Under the best-case conditions, these values should be compared to values computed from measurements of excess pore pressures or settlement rates during construction of other structures.

CPTu tests in which the pore pressure dissipation rate is measured may be used to estimate the field coefficient of consolidation.

For preliminary analyses or where accurate prediction of settlement is not critical, values obtained from correlations to index properties presented in Sabatini et al. (2002) may be used.

Where evaluation of elastic settlement is critical to the design of the foundation or selection of the foundation type, in-situ methods such as PMT or *DMT* for evaluating the modulus of the stratum should be used.

For preliminary design or for final design where the prediction of deformation is not critical to structure performance, i.e., the structure design can tolerate the potential inaccuracies inherent in the correlations. The elastic properties (E_s, ν) of a soil may be estimated from empirical relationships presented in Table C10.4.6.3-1.

The specific definition of E_s is not always consistent for the various correlations and methods of in-situ measurement. See Sabatini et al. (2002) for additional details regarding the definition and determination of E_s.

An alternative method of evaluating the equivalent elastic modulus using measured shear wave velocities is presented in Sabatini et al. (2002).

Table C10.4.6.3-1—Elastic Constants of Various Soils (modified after U.S. Department of the Navy, 1982; Bowles, 1988)

Soil Type	Typical Range of Young's Modulus Values, E_s (ksi)	Poisson's Ratio, ν (dim)
Clay:		
Soft sensitive		
Medium stiff to stiff	0.347–2.08	0.4–0.5 (undrained)
	2.08–6.94	
Very stiff	6.94–13.89	
Loess	2.08–8.33	0.1–0.3
Silt	0.278–2.78	0.3–0.35
Fine Sand:		
Loose	1.11–1.67	0.25
Medium dense	1.67–2.78	
Dense	2.78–4.17	
Sand:		
Loose	1.39–4.17	0.20–0.36
Medium dense	4.17–6.94	
Dense	6.94–11.11	0.30–0.40
Gravel:		
Loose	4.17–11.11	0.20–0.35
Medium dense	11.11–13.89	
Dense	13.89–27.78	0.30–0.40

Estimating E_s from *SPT N* Value	
Soil Type	E_s (ksi)
Silts, sandy silts, slightly cohesive mixtures	0.056 $N_{1,60}$
Clean fine to medium sands and slightly silty sands	0.097 $N_{1,60}$
Coarse sands and sands with little gravel	0.139 $N_{1,60}$
Sandy gravel and gravels	0.167 $N_{1,60}$
Estimating E_s from q_c (static cone resistance)	
Sandy soils	$0.028q_c$

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Es = 800 ksf = 5.56 ksi
Poisson's Ratio = 0.40

The modulus of elasticity for normally consolidated granular soils tends to increase with depth. An alternative method of defining the soil modulus for granular soils is to assume that it increases linearly with depth starting at zero at the ground surface in accordance with the following equation:

$$E_s = nh \times z \qquad \text{(C10.4.6.3-1)}$$

where:

Appendix D.3 - Wall 05.55L Design Calculations

AASHTO Average Blowcount in Upper 100 feet

W-215-20							
Depth	Field Blowcount	Energy Corrected Blowcount, N_i	Layer thickness d_i (feet)	Sum(d_i)	d_i/N_i	Sum(d_i/N_i)	N_{ave}
2.5	46	67	3.75	100	0.06	2.1622	**46.3**
5	32	46	2.5		0.05		
7.5	32	46	2.5		0.05		
10	39	57	3.75		0.07		
15	23	33	5		0.15	Driving Energy	87%
20	51	74	5		0.07		
25	34	49	5		0.10		
30	31	45	72.5		1.61		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
					End of Data		
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					End of Data		
					End of Data		

Soil Profile Type	v_s (fps)	N
S_A	>5000	N/A
S_B	2,500 to 5,000	
S_C	1,200 to 2,500	>50
S_D	600 to 1,200	15≤N≤50
S_E	<600	<15

Table 3.10.3.1-1—Site Class Definitions from AASHTO

Name	Nave	Soil Profile Type
W-215-20	46.3	D

Note:

Blowcount Percent (Energy is input BC/60). This spreadsheet approximates the layer thickness based on a function with depth, however, depending on the layering of the log, it may be necessary for the user to input their own layer thicknesses (i.e., clay layer extends at 7.5 ft and the blowcounts need to be weighted to reflect that thickness).

Spreadsheet based on Section 3.10.3.1 of American Association of State Highway and Transportation Officials (AASHTO).

Password Average_Blow_Count

05.55L

BEToolbox™

Spectra

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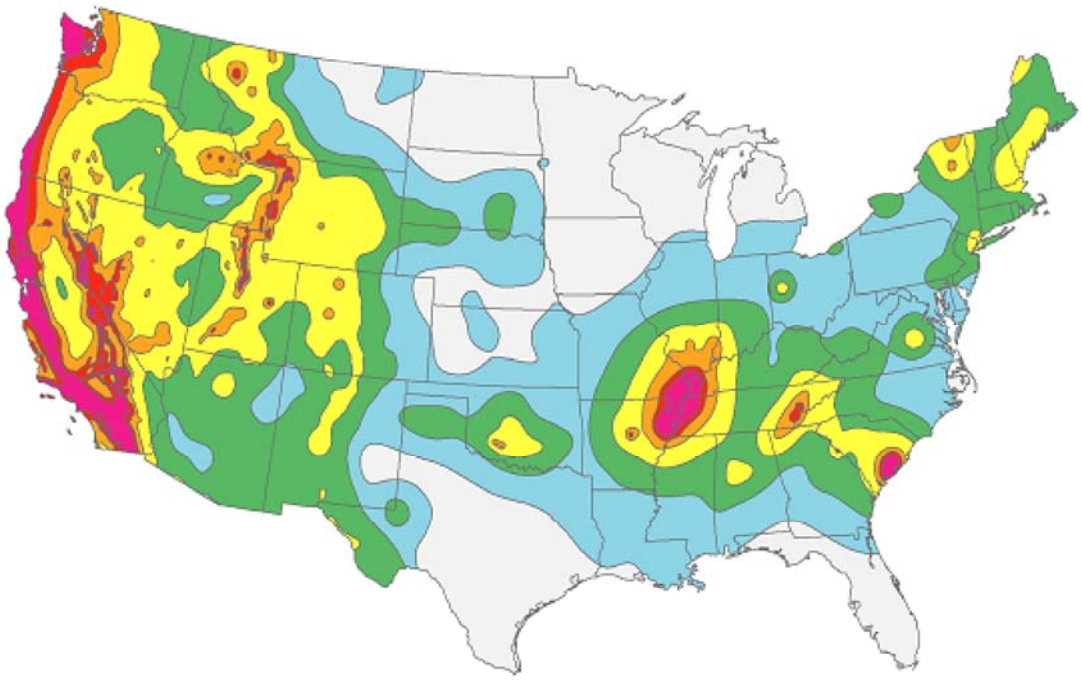
Version 6.0.0.6 BETA - Built on Jan 7 2021



05.55L

WSDOT Bridge Design Manual
2014 Seismic Hazard Map, 7% probability of exceedance in 75 years

Site Coordinates (Latitude,Longitude): 47.5054° N, 122.198° W
Site Soil Classification: Site Class D - Stiff Soil

Seismic hazard maps are for sites at the boundary of Site Classes B and C, which is $\bar{v}_s$ = 2500 ft/s (760 m/s). Adjustments for other Site Classes are made as needed.

Period (sec)	Sa (g)	
0.0	0.433	PGA - Site Class B/C Boundary
0.2	0.986	S_s - Site Class B/C Boundary
1.0	0.283	S_1 - Site Class B/C Boundary

Values of Site Coefficient, F_{pga}, for Peak Ground Acceleration

Site Class	Mapped Peak Ground Acceleration Coefficient (PGA)					
	PGA≤ 0.10	PGA= 0.20	PGA= 0.30	PGA= 0.40	PGA= 0.50	PGA≥ 0.60
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.2	1.2	1.2	1.2	1.2
D	1.6	1.4	1.3	1.2	1.1	1.1
E	2.4	1.9	1.6	1.4	1.2	1.1

For Site Class D, F_{pga} = 1.167

Values for Site Coefficient, F_a, for 0.2 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 0.2 sec (S_s)					
	S_s≤ 0.25	S_s= 0.50	S_s= 0.75	S_s= 1.00	S_s= 1.25	S_s≥ 1.50
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	1.0	0.9	0.9

For Site Class D, F_a = 1.106

Values of Site Coefficient, F_v, for 1.0 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 1.0 sec (S_1)					
	S_1≤ 0.1	S_1= 0.2	S_1= 0.3	S_1= 0.4	S_1= 0.5	S_1≥ 0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2	2.0	1.9	1.8	1.7
E	4.2	3.3	2.8	2.4	2.2	2.0

For Site Class D, F_v = 2.035

$A_s = F_{pga}$ PGA = (1.167)(0.433g) = 0.505g
$S_{DS} = F_a S_s$ = (1.106)(0.986g) = 1.090g
$S_{D1} = F_v S_1$ = (2.035)(0.283g) = 0.575g
$T_o = 0.2T_s$ = (0.2)(0.528) = 0.106 sec
$T_s = S_{D1}/S_{DS}$ = (0.575)/(1.090) = 0.528 sec

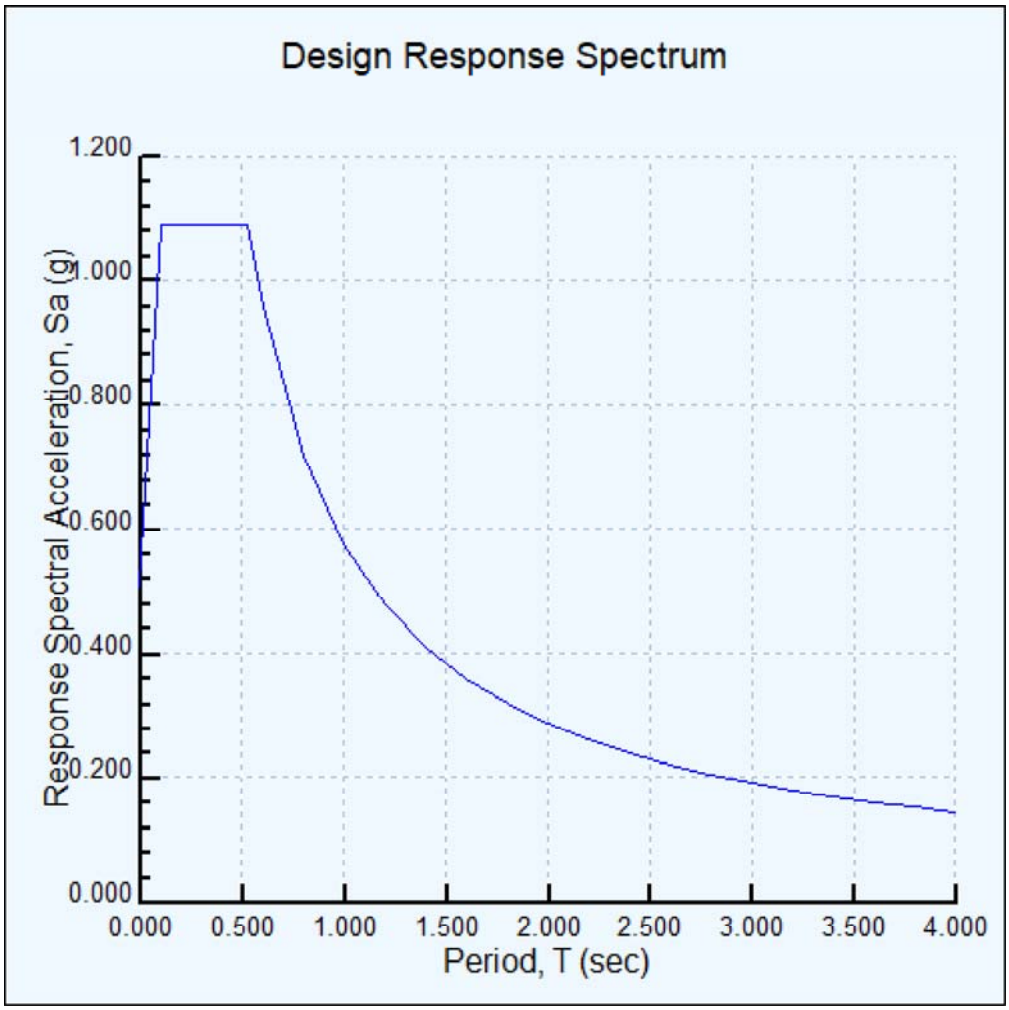
05.55L

Partitions for Seismic Design Categories A, B, C, and D

S_{D1}	SDC
$S_{D1} < 0.15$	A
$0.15 \le S_{D1} < 0.30$	B
$0.30 \le S_{D1} < 0.50$	C
$0.50 \le S_{D1}$	D

Seismic Design Category (SDC) = D

Period, T (sec)	Sa (g)	
0.000	0.505	
0.106	1.090	T_o
0.200	1.090	
0.400	1.090	
0.528	1.090	T_s
0.600	0.959	
0.800	0.719	
1.000	0.575	
1.200	0.479	
1.400	0.411	
1.600	0.359	
1.800	0.320	
2.000	0.288	
2.200	0.261	
2.400	0.240	
2.600	0.221	
2.800	0.205	
3.000	0.192	
3.200	0.180	
3.400	0.169	
3.600	0.160	
3.800	0.151	
4.000	0.144	



General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	W-215-20
Analysis by:	BZ
Date Analyzed:	1/27/2021
Checked by:	YT
Date Checked:	3/10/2021

Sampling Information	
Depth to Groundwater (ft):	31
SPT Liner (Yes/No):	No
Hammer Energy, %:	87
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	8

GW observed ATD

Earthquake Information	
Max Acceleration (As) (g) :	0.505
Earthquake Magnitude:	7.00

Site Class D SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Collect Data From gINT | Automate %F from USCS

Auto %F from WSDOT GDM | **COMPUTE**

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	2.5	46	SM	30	ESU 1B	130		Unsaturated	
	5.0	32	SM	27	ESU 1B	120		Unsaturated	
	7.5	32	SM	23	ESU 1B	120		Unsaturated	
	10.0	39	SM	23	ESU 1B	125		Unsaturated	
	15.0	23	ML	72	ESU 4B	110		Non-Liquefiable	Non-Liquefiable
	20.0	51	SM	23	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	25.0	34	SM	23	ESU 4B	120		Non-Liquefiable	Non-Liquefiable
	30.0	31	ML	70	ESU 4B	110		Non-Liquefiable	Non-Liquefiable

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	2.5	46	SM	30	94	94	2.00	2.00	0.0	0.0	0.0	0.0	94.2	97.8	92.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	5.0	32	SM	27	63	59	2.00	2.00	0.0	0.0	0.0	0.0	58.8	72.6	59.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.5	32	SM	23	57	53	2.00	2.00	0.0	0.0	0.0	0.0	53.1	64.6	53.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	10.0	39	SM	23	68	64	2.00	2.00	0.0	0.0	0.0	0.0	63.7	72.3	64.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	15.0	23	ML	72	39	38	2.00	2.00	0.0	0.0	0.0	0.0	38.2	39.6	37.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	20.0	51	SM	23	76	78	2.00	2.00	0.0	0.0	0.0	0.0	77.8	75.3	75.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	25.0	34	SM	23	45	49	2.00	2.00	0.0	0.0	0.0	0.0	49.0	45.0	46.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	30.0	31	ML	70	39	45	2.00	2.00	0.0	0.0	0.0	0.0	45.0	39.7	41.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

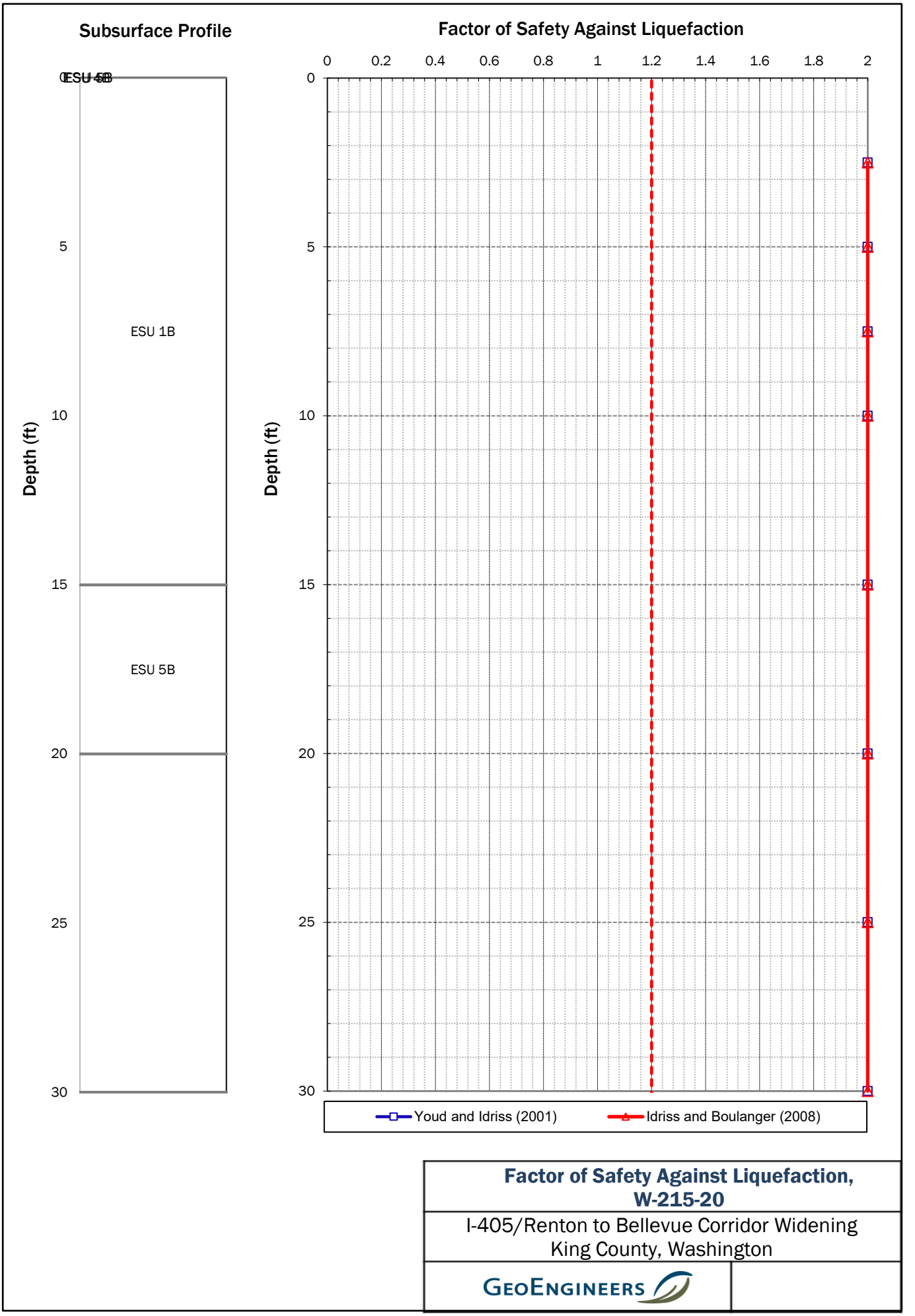
Seismic Parameters	
Max Acceleration (As) (g) :	0.505
Earthquake Magnitude:	7.00

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, W-215-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

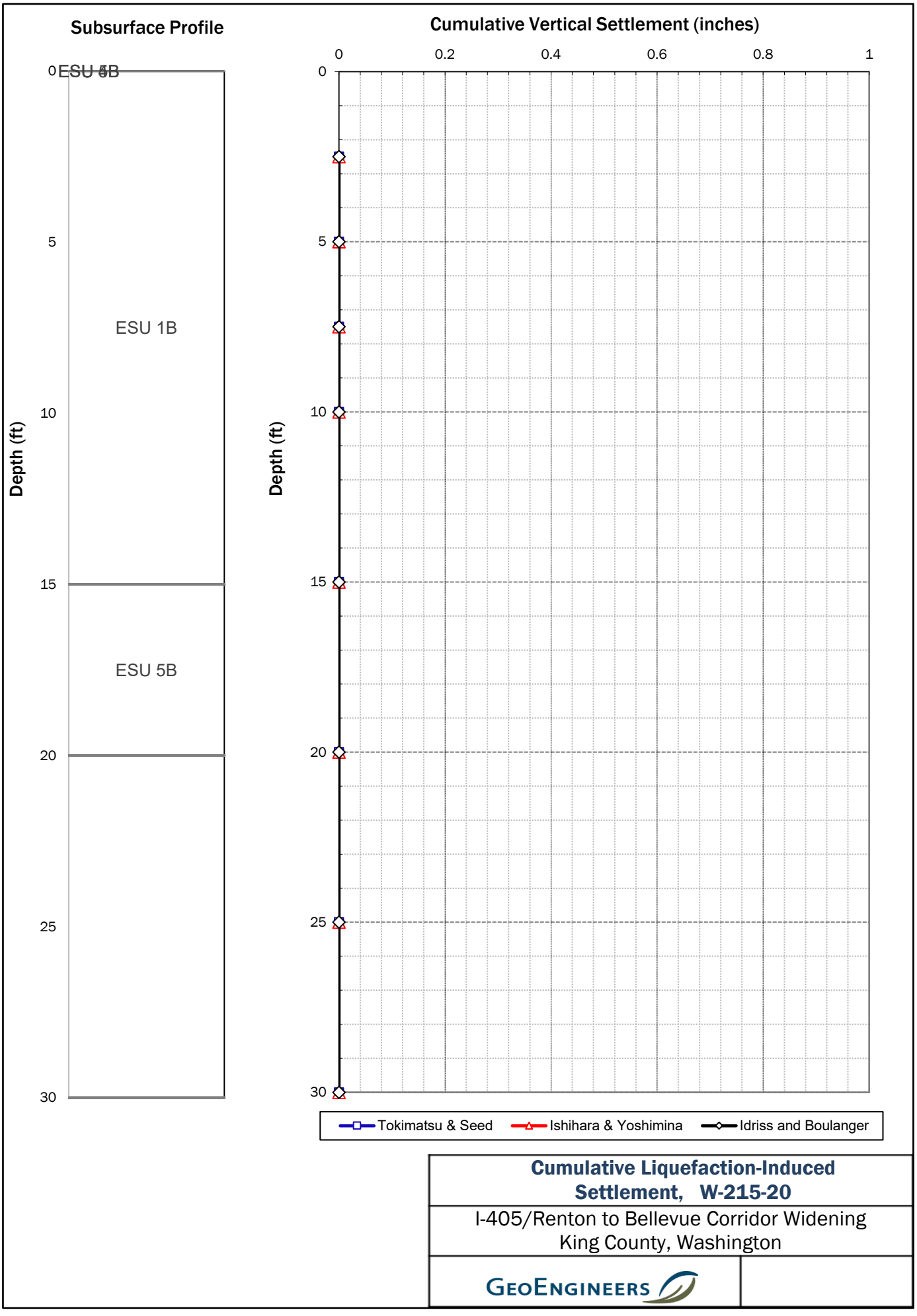


Factor of Safety Against Liquefaction, W-215-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 3/10/2021



Cumulative Liquefaction-Induced Settlement, W-215-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 3/10/2021

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	I-405/Renton to Bellevue Corridor Widening
Owner:	WSDOT
Job Number:	00180-366-01
Analysis by:	YTT
Date/Time:	1/12/2022 11:40 AM
Checked by:	TB

Input Parameters

Material	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
Common Borrow	32	-15	0	21	0	0	120	57.6	1	0.253	0
Select Borrow	36	-15	0	24	0	0	125	62.6	1	0.253	0
Gravel Borrow	38	-15	0	25	0	0	130	67.6	1	0.253	0

Lateral Earth Pressures

Output

Material	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic				Seismic Pressure - Rectangular
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], X	K_{ae}	γ_{ae} (pcf)	γ'_{ae} (pcf)	K_{pe}	(psf * H)
Common Borrow	0.28	33.00	15.84	2.00	240.13	115.26	571.32	274.23	0.47	56.41	27.08	33.00	33.00	0.48	57.47	27.59	4.76	12.23
Select Borrow	0.23	29.36	14.70	2.30	287.97	144.21	801.00	401.14	0.41	51.53	25.80	29.36	29.36	0.42	52.60	26.34	6.41	11.62
Gravel Borrow	0.22	28.18	14.65	2.47	321.67	167.27	978.48	508.81	0.38	49.96	25.98	28.18	28.18	0.39	51.33	26.69	7.53	11.58

Recommended Lateral Earth Pressures

		Sliding Friction Coefficient
Soil Type	φ'	Cast-In-Place Concrete
Common Borrow	32	0.62
Select Borrow	36	0.73
Gravel Borrow	38	0.78
ESU 1B	40	0.84

Notes:
Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2

Cast-In-Place Concrete Coefficient of Friction:
Coefficient of friction = 1.0*tan(Phi')

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for concrete cast against soil
= 0.8 for precast concrete footing

where:

ϕ_f = internal friction angle of drained soil (degrees)
V = total vertical force (kips)

LRFD Foundation Design

Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications

Date/Time:	1/11/22 10:25 AM
Project Name:	**I-405/Renton to Bellevue Corridor Widening - Wall 05.55L**
Project No.:	**00180-366-01**

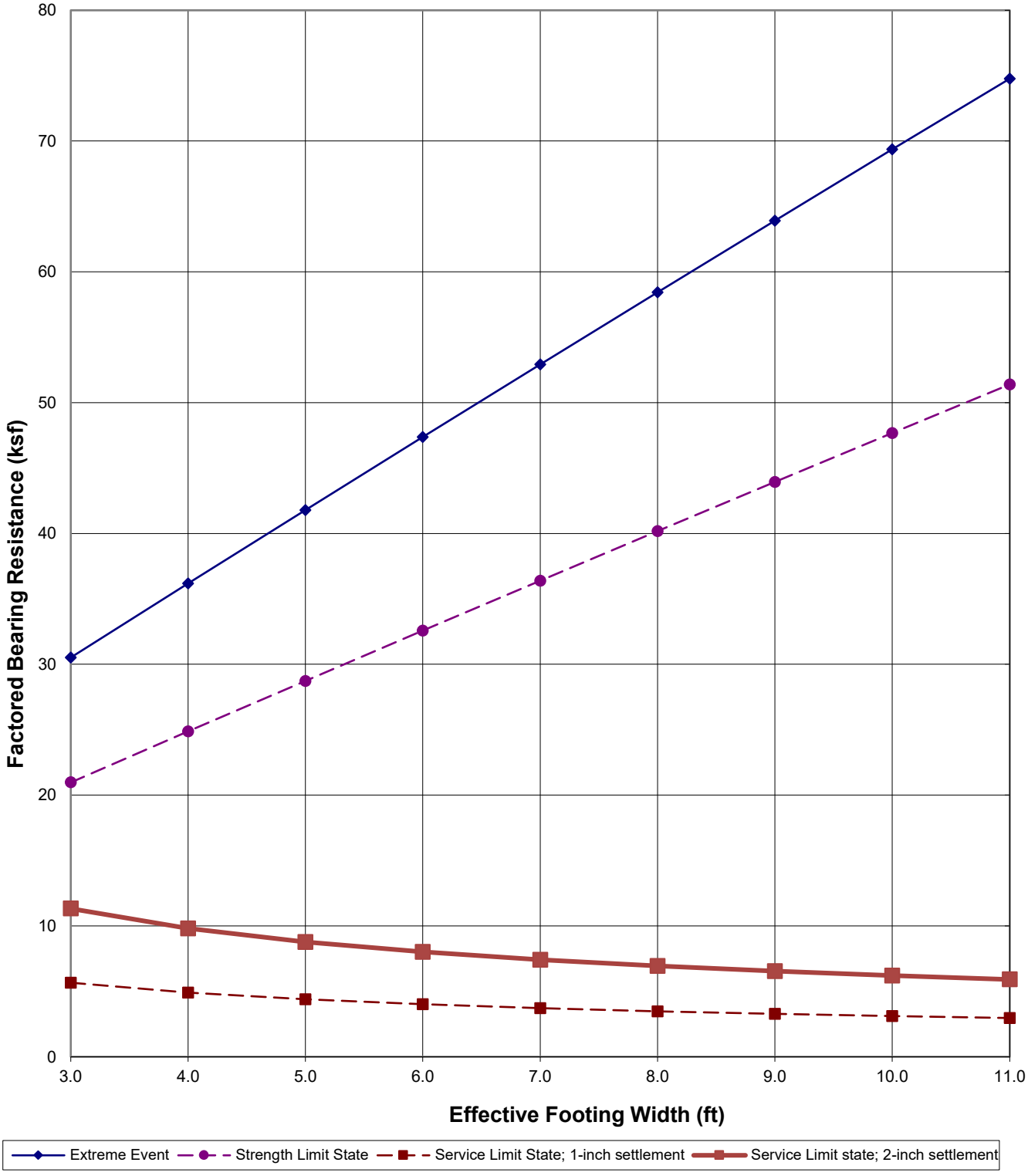
Foundation Soil Conditions		
Unit Weight, γ (pcf)	**130**	(ESU 1B)
Friction angle, Φ (degrees)	**40**	
Friction angle, Φ (rad)	0.698	
Cohesion, C (psf)	**0**	
Embedment, D_f (ft)	**2**	
Depth to Groundwater, D_w (ft)	**26**	
Footing Length, L (ft)	**130**	
Footing Width, B (ft)	**1**	
Poissons Ration, ν	**0.40**	
Young's Modulus, E_s (ksf)	**800**	

Bearing Capacity Factors	
N_γ	109
N_c	75
N_q	64

Effective Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.8) for gravity and semigravity walls (Section 11.5.8 AASHTO)	**Working Bearing Resistance** Resistance Factor (0.55) for gravity and semigravity walls (Table Table 11.5.7-1)	Deflection from Elastic Settlement Spreadsheet **1" Deflection**	Deflection from Elastic Settlement Spreadsheet **2" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
3.0	1.0	1.0	1.02	0.99	1.02	38.2	30.5	21.0	5.7	11.3
4.0	1.0	1.0	1.03	0.99	1.03	45.2	36.2	24.9	4.9	9.8
5.0	1.0	1.0	1.03	0.98	1.03	52.2	41.8	28.7	4.4	8.8
6.0	1.0	1.0	1.04	0.98	1.04	59.2	47.4	32.6	4.0	8.0
7.0	1.0	1.0	1.05	0.98	1.05	66.2	52.9	36.4	3.7	7.4
8.0	1.0	1.0	1.05	0.98	1.05	73.0	58.4	40.2	3.5	6.9
9.0	1.0	1.0	1.06	0.97	1.06	79.9	63.9	43.9	3.3	6.5
10.0	1.0	1.0	1.07	0.97	1.06	86.7	69.4	47.7	3.1	6.2
11.0	1.0	1.0	1.07	0.97	1.07	93.5	74.8	51.4	3.0	5.9

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing are to be excavated.

Wall 05.55L Bearing Resistance



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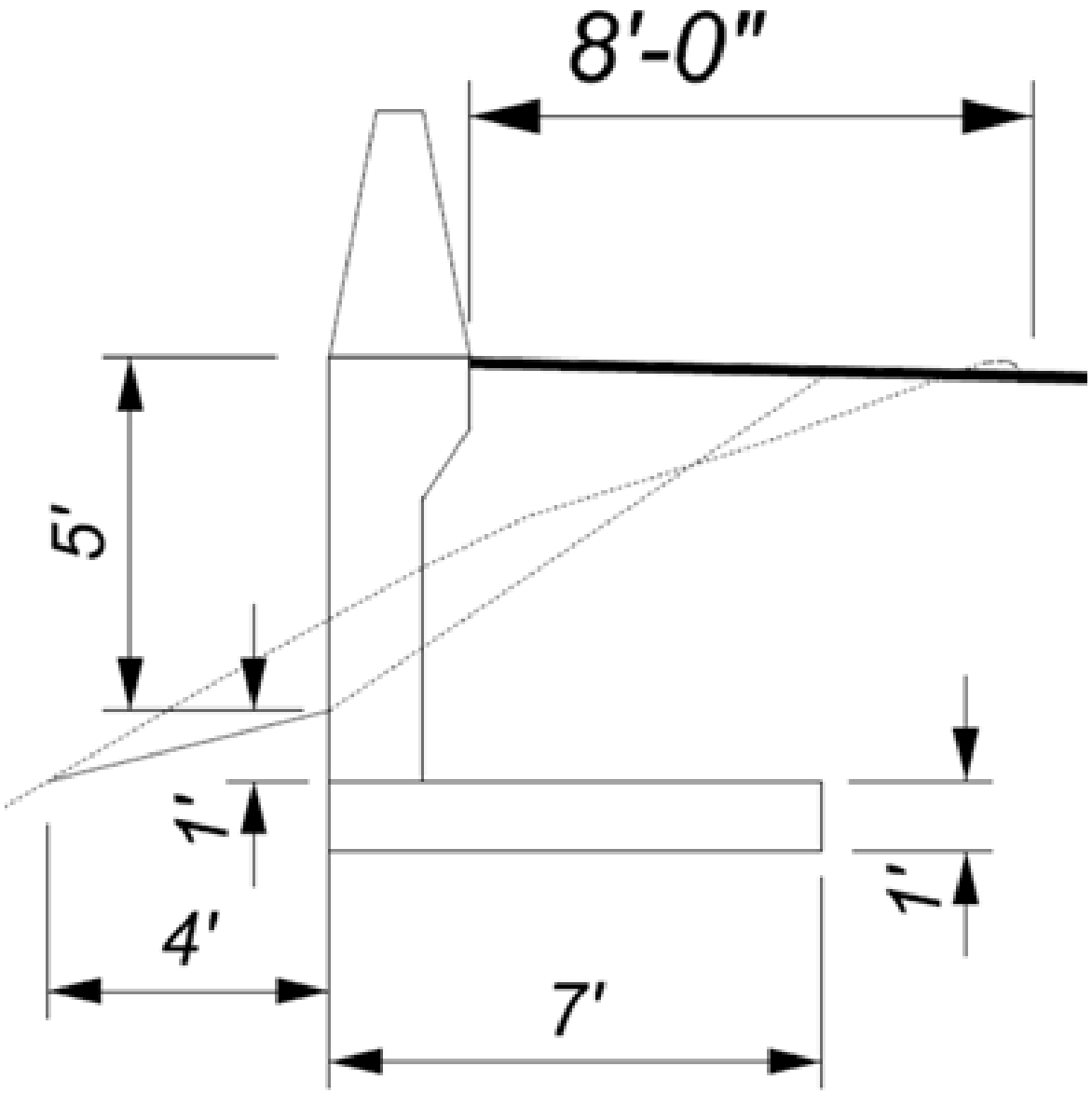
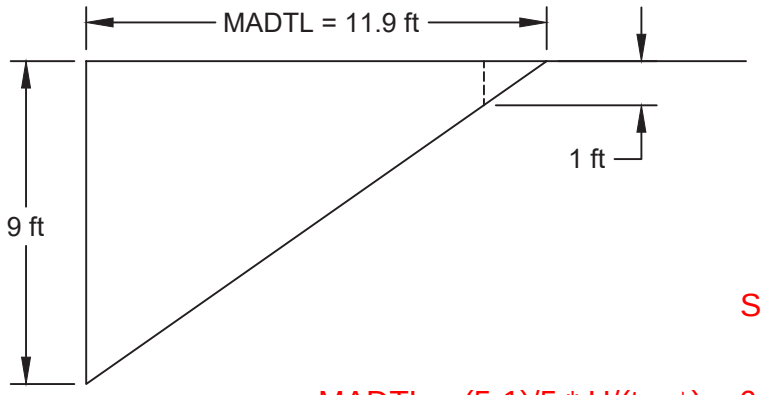
Shallow Foundation Design



Wall 05.55L dimensions provided by Wood on November 17, 2021

Cast-in-Place or Precast Wall

Assumed Deformation Profile

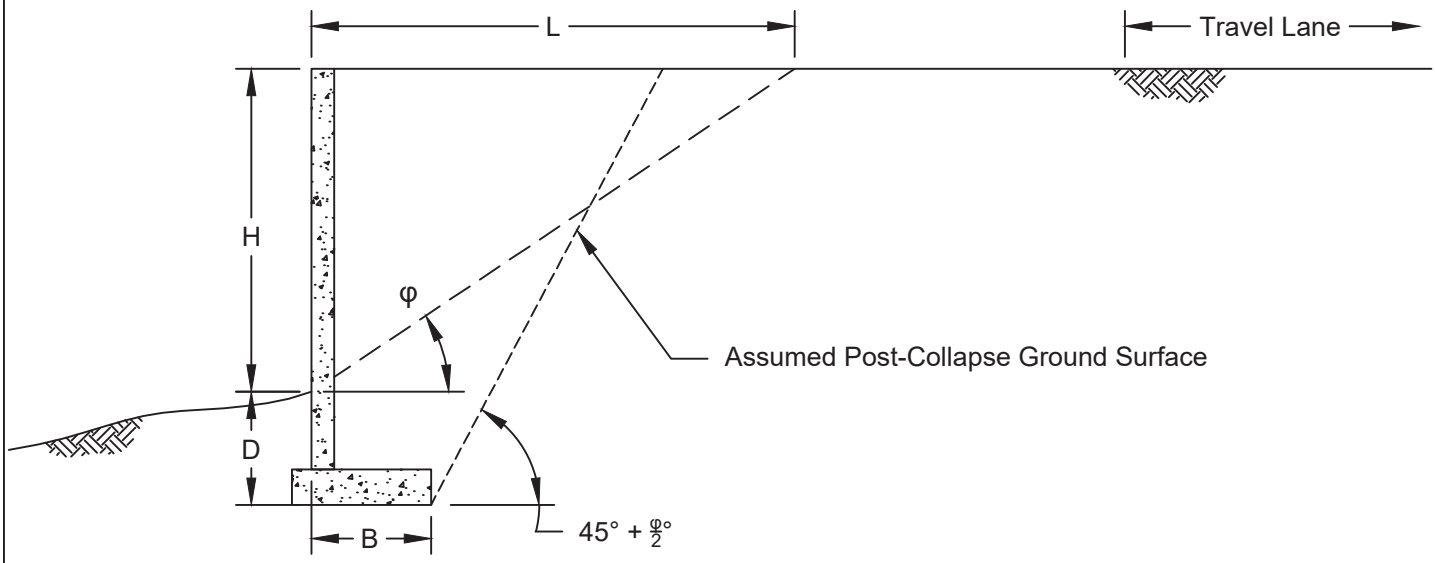


Wall 05.55L

H = 5 feet
ϕ = 32 degrees
Shoulder width = 8 feet

MADTL = (5-1)/5 * H/(tanϕ) = 6.4 feet < 8-foot shoulder

Assumed Failure Geometry



MADTL = Minimum Allowable Distance to Travel Lane = $\frac{H - 1}{H} * \frac{H}{\tan(\varphi)}$

Where:
φ = Internal friction angle of wall backfill material (assume 34 degrees if unknown)
B = distance from wall face to back edge of wall footing or reinforced zone
H = exposed height of wall

NOT TO SCALE

Note: The assumed 1-foot vertical deformation (shown above) is representative of an "abrupt elevation change" within the traveled way and is used to define the minimum wall offset from the traveled way.

I-405 R2B Express Toll Lanes
King County, Washington

Minimum Allowable Distance to Travel Lane - Wall Below Travel Lane

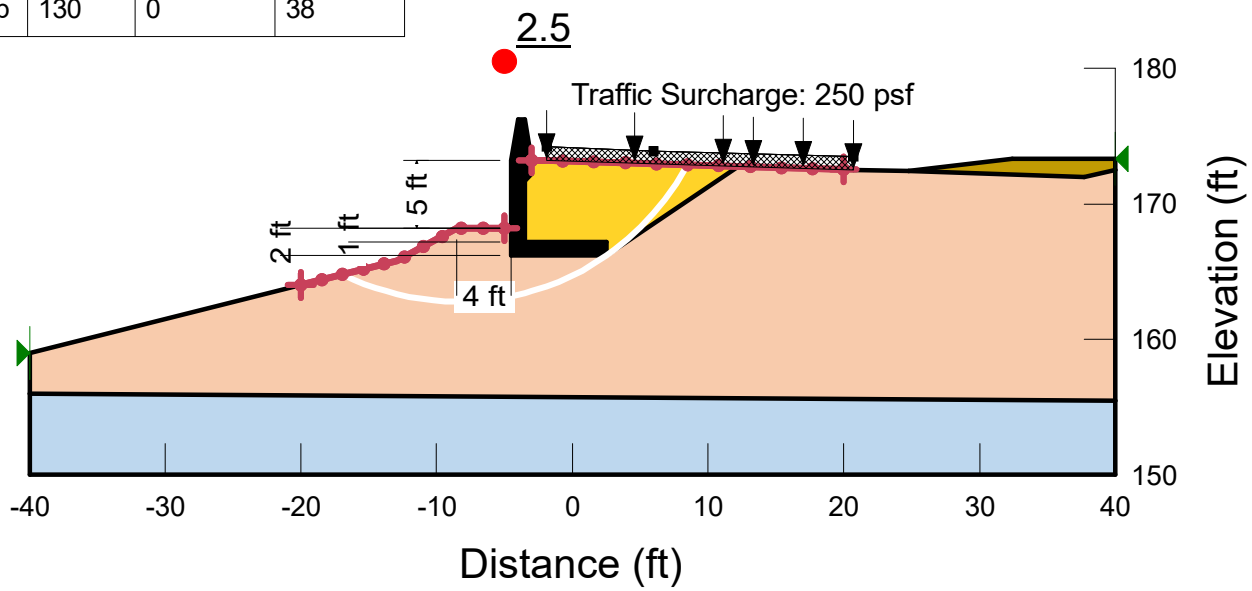
19434-03 10/20

HARTCROWSER
A division of Haley & Aldrich

Figure
1A

File: L:\Notebooks\1943403_WSDOT_I-405_Advisory Scope\CAD\1943403-001 (Traffic).dwg Layout:Cast-in-Place Date: 10-12-2020 Author: evinfairchild

Color	Name	Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Barrier	High Strength	150		
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	40
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	120	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Wall 05.55L - Sta. 1+50
Static Global Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

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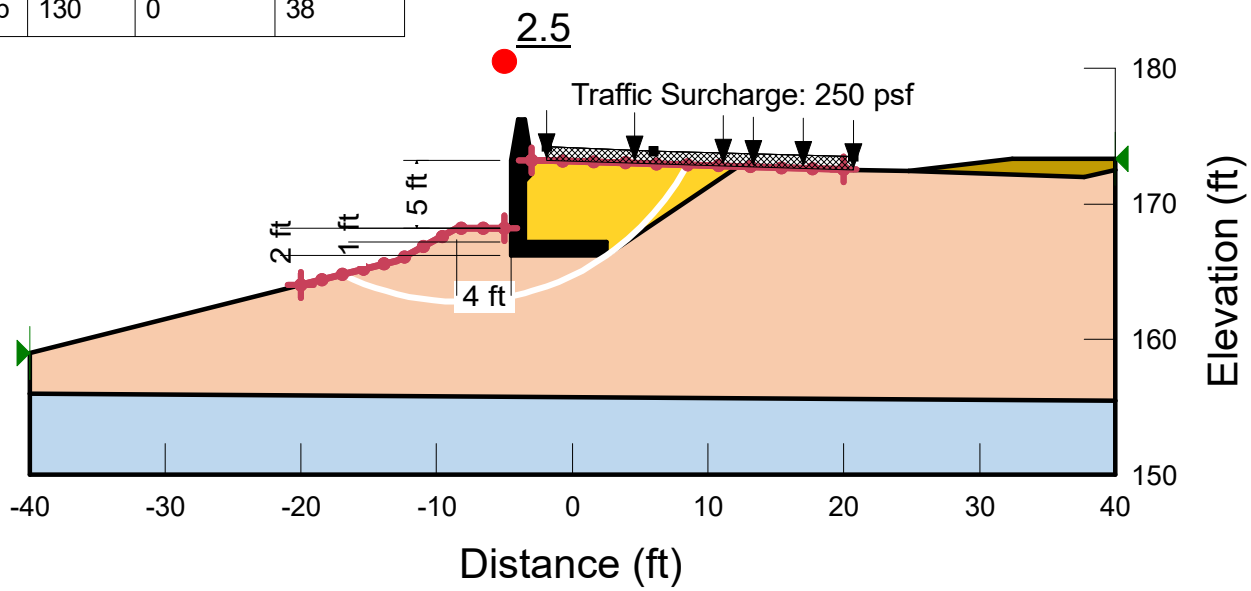
Color	Name	Material Model	Unit Weight	Effective Cohesion	Effective Friction Angle
	Barrier	High Strength	150		
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	40
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	120	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Wall 05.55L - Sta. 1+50
Static Global Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 01/11/22

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Appendix E
Wall 05.85L-A Calculations

APPENDIX E - WALL 05.85L-A CALCULATIONS

General

This appendix presents geotechnical calculations for Wall 05.85L-A including:

- ESU Soil Properties
- Seismic Hazard Analysis
- Lateral Earth Pressures
- Coefficients of Friction for Sliding
- Bearing Resistance and Elastic Settlement
- Seepage Analysis
- Global Stability
- Compound Stability

ESU Soil Properties

Design soil properties were developed in accordance with the Project GDM, AASHTO LRFD, FHWA, WSDOT HRM, and the USGS. We calculated the average, geometric mean, and standard deviation within each ESU. We verified the reliability of the ESU data set by comparing the COV of each calculated geometric mean value to measured and interpreted values presented in Sabatini et al. (2002) Table 52.

A detailed description of the soil property development is presented in Section 7.1 of this geotechnical engineering report. Supporting calculations are provided in this appendix.

Seismic Hazard Analysis

We selected a representative site class for the wall from the site class evaluation of nearby borings. We evaluated the site class of each boring using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 3.10.3.1.

We developed seismic design parameters using the WSDOT Bridge Engineering Software BEToolbox/BridgeLink in accordance with the WSDOT BDM based on the projected ground motion at the project site that has a 7 percent (SEE) probability of exceedance in a 75-year period (approximate 1,000-year return period).

We used a mean earthquake magnitude at the PGA period is 7.0 for the SEE based on the Hart Crowser design report "I-405 R2B Segment 1a Site-Specific Hazard Analysis RFU," dated March 25, 2021.

We evaluated the FS against liquefaction and liquefaction-induced settlement of saturated, loose to medium dense soils in accordance with the Project GDM Chapter 6 using a spreadsheet developed by GeoEngineers. Per Project GDM Section 6-4.2.3, soils with liquefaction potential are defined as those with FSs against liquefaction less than 1.2. Our analysis shows that saturated, low-plasticity portions of ESU 2B at Wall 05.85L-A may be liquefiable. Estimated liquefaction-induced settlement at Wall 05.85L-A ranges from 2 to 4 inches, considering the full thickness of ESU 2B present at H-2-85. We estimate that differential liquefaction settlements in ESU 2B could be on the order of 1 to 2 inches. However, based on the planned base of wall elevation, we do not anticipate that a significant thickness of ESU 2B will remain below the base of the wall. In addition, based on our groundwater model, we anticipate that any ESU 2B material remaining below the wall will not be saturated. Therefore, we do not anticipate liquefaction or related settlement of soil beneath the wall. Saturated portions of ESU 2B downslope of the wall may experience liquefaction and related settlement.

Residual shear strength was calculated for liquefiable soils from existing relationships and procedures outlined in Project GDM Section 6-2.2 using a spreadsheet developed by GeoEngineers. Residual strength calculations become unconservatively high for liquefiable soils with an $N1_{60}$ corrected to an equivalent clean sand [$N1_{60}$(cs)] that is greater than 20. Using guidance presented in WSDOT Report WA-RD 668.1 (Kramer 2008), we capped $N1_{60}$(cs) to 20 to calculate a residual shear strength for soils exhibiting liquefaction potential (FS against liquefaction < 1.2).

Detailed descriptions of our seismic hazard analysis methodology and the results are presented in Section 7.2 and Section 8.1, respectively, of this report. Site class calculations, WSDOT BDM software outputs, liquefaction analyses, and residual shear strength calculations are provided in this appendix.

Lateral Earth Pressures

Active static lateral pressure coefficients and corresponding lateral earth pressures for ESU 2A were calculated on the back of Wall 05.85L-A in accordance with AASHTO LRFD Section 3.11.5 using the proposed 2H:1V backslope behind the wall and 2H:1V foreslope in front of the wall. Static lateral earth pressures shall be applied using a triangular distribution. An LRFD load factor of 1.5 shall be applied to the static earth pressures in accordance with AASHTO LRFD Table 3.4.1-2.

Due to relatively shallow embedment of the wall combined with a foreslope condition, passive lateral earth pressures shall be ignored.

Active static + seismic lateral pressure coefficients and static + seismic lateral earth pressures were calculated using the GLE Method in accordance with AASHTO LRFD Section A11.3.3 and NCHRP Report 611 Section 7.4. The GLE analysis was evaluated for Spencer's method using the computer design software Slope/W (Geo Slope International, Ltd. 2020). For the static + seismic earth pressures, we used a modified horizontal seismic coefficient, kh, coupling a 50 percent reduction for flexible wall displacements with a reduction for wave scattering effects. Static + seismic lateral earth pressures shall be applied using a triangular distribution. An LRFD load factor of 1.0 shall be applied to the static + seismic earth pressures in accordance with AASHTO LRFD Table 3.4.1-1.

Surcharge loads (such as traffic loading, fill loads above the wall, and forward compatible loading for future I-405 widening) and appropriate load factors shall be applied to evaluate wall stability. All surcharges shall apply load factors in accordance with AASHTO LRFD Tables 3.4.1-1 and 3.4.1-2.

A detailed description of our analysis methodology and the calculated results are presented in Section 7.3 and Section 8.2, respectively. Supporting calculations are provided in this appendix.

Coefficients of Friction for Sliding

Coefficients of friction for sliding on surficial native soils, common borrow, select borrow, and gravel borrow were calculated using AASHTO LRFD equation 10.6.3.4-2.

A detailed description of our analysis methodology and the results are presented in Section 7.4 and Section 8.3, respectively, of this report. Supporting calculations are provided in this appendix.

Bearing Resistance and Elastic Settlement

We estimated the bearing resistance and elastic settlement of the wall using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 10.6.3. We estimated elastic settlement from procedures outlined in AASHTO LRFD and Section 10.6.2.4. Sliding, overturning, and internal stability are being evaluated by the design-build team's wall designers and will be submitted under separate cover.

A detailed description of our analysis methodology and the results are presented in Section 7.5 and Section 8.4, respectively, of this report. Supporting calculations are provided in this appendix.

Seepage Analysis

We used finite element seepage modeling software, Seep/W, to estimate a steady state groundwater level at the wall. We used existing groundwater measurements from piezometers in borings H-2-85 and H-3-85, subsurface soil hydraulic conductivity properties, and precipitation data to develop a conceptual model of seepage patterns.

A detailed description of our analysis methodology is presented in Section 7.7, and discussion of the model development and conclusions is presented in Section 8.5 of this report. Steady-state seepage results are presented in this appendix. Seep/W output reports are provided in Appendix I.

Global Stability

We performed global stability analyses for the following critical design section:

- Section Sta. 1+90 – Maximum overall slope height

Global stability was evaluated using limit equilibrium analysis methodology outlined in the Project GDM using the computer design software Slope/W (Geo Slope International, Ltd. 2020). We analyzed FSs using Spencer's method and Morgenstern-Price for a circular failure surface.

We used an apparent cohesion in the surficial native soils for pseudo-static analyses. Apparent cohesion was based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3.

We evaluated post-seismic global stability using residual shear strengths for potentially liquefiable soil.

We modeled a 4-foot horizontal bench in front of the wall per AASHTO LRFD Section 11.10.2.2 and a front face embedment depth of 3 feet using criteria outlined in AASHTO LRFD Table C11.10.2.2-1.

To meet minimum FSs, we used a minimum reinforcement length of 0.8H to model the SEW. We modeled a 1.5-foot clearance between the reinforced zone and the temporary shoring, which was backfilled with imported gravel borrow. See Section 8.8.3 in this geotechnical report for discussion on temporary shoring.

We used the horizontal seismic coefficient, kh, for global stability presented in Table 8 of this geotechnical report for the pseudo-static global stability analyses. We used the residual shear strength presented in Table 5 of this geotechnical report for liquefiable soils to evaluate post-seismic global stability.

A uniform traffic surcharge of 250 psf was included in static stability analysis. A uniform traffic surcharge of 125 psf was included for the seismic (pseudo-static and post-seismic) stability analyses. In accordance with Section 15-4.12 of the Project GDM, we used a load factor of 1.0 for the static traffic surcharge because it is a non-structural load.

The groundwater level was modeled using results from the seepage analysis.

We also evaluated the global stability of the wall with a forward compatible wall for future I-405 widening. We modeled the forward compatible wall directly above the proposed SEW with the face of the forward compatible wall set back 7 feet from the face of the SEW. We modeled the backfill behind the forward compatible wall as lightweight EPS using the strength properties presented in Table 7 and truncated the EPS behind the forward compatible wall at 4 feet from the proposed edge of the traveled way. The required minimum static, pseudo-static, and post-seismic FSs were met for all forward compatible wall cases.

Detailed descriptions of our global stability analysis methodology and the results of our analyses are presented in Section 7.8 and Section 8.6, respectively, of this report. Global stability models showing FS for critical failures at the design section are provided in this appendix. Slope/W reports are provided in Appendix J.

Compound Stability

We used the results of the global stability analyses to model and evaluate compound stability at the critical design section using the minimum reinforcement lengths required to meet the minimum FSs from the global stability analyses. To meet minimum FSs for compound stability, we kept the upper 6 rows of reinforcing strips at a length of 0.8H (2 strips per row per panel), but for the bottom 2 rows, we increased the length of reinforcing strips to 1.0H and increased the number of reinforcing strips to 4 per row per panel.

We used the horizontal seismic coefficient, kh, for compound stability presented in Table 8 and applied the apparent cohesion presented in Table 5 for the pseudo-static analysis. We used the residual shear strength presented in Table 5 for liquefiable soils to evaluate post-seismic compound stability.

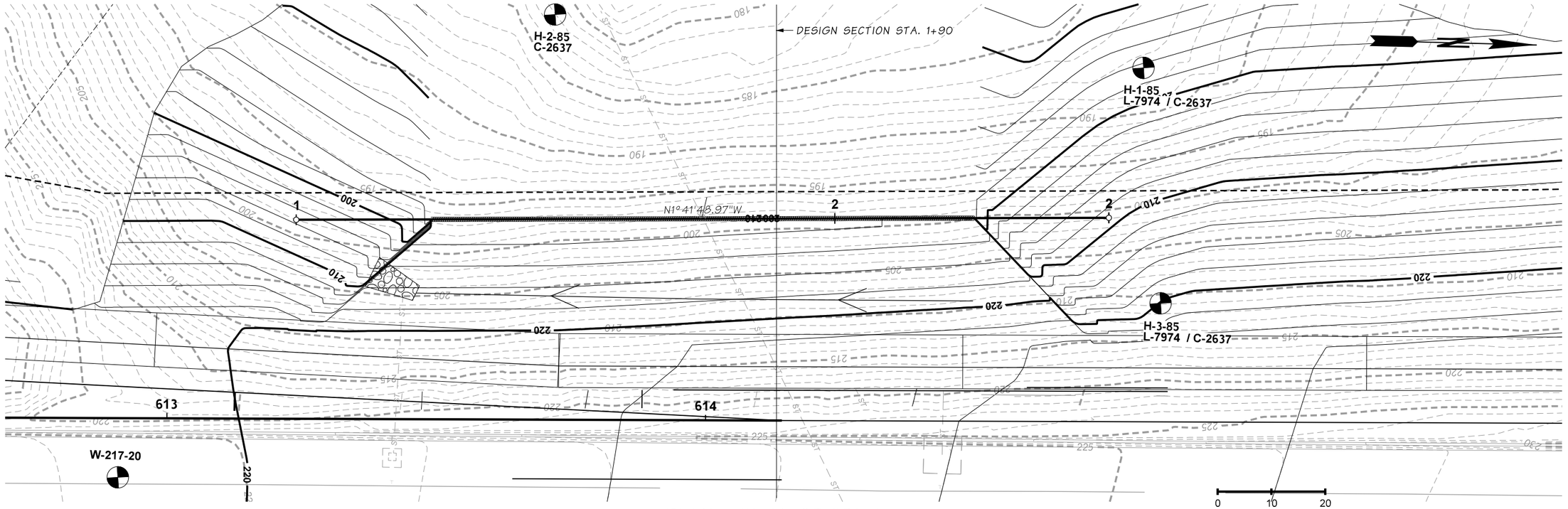
We applied a uniform traffic surcharge of 437.5 psf directly over the reinforced zone and a uniform traffic surcharge of 250 psf outside of the reinforced zone for the static compound stability analysis, and a traffic surcharge of 125psf for the seismic (pseudo-static and post-seismic) compound stability analysis.

We used the piezometric surface from the seepage analysis to model the groundwater level.

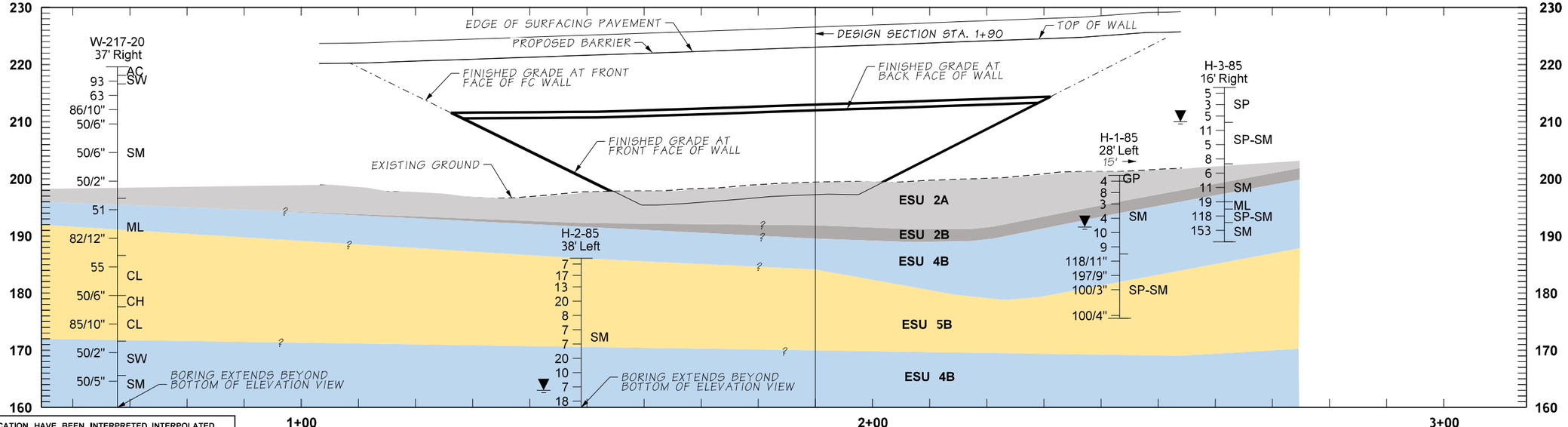
We also evaluated the compound stability of proposed Wall 05.85L-A considering forward compatible walls for future I-405 widening, using the same geometry and strength properties from the global stability analyses for the forward compatible wall. As one option to meet required compound stability minimum FSs, we modeled the backfill as lightweight EPS. We did not explore all potential options as design of the forward compatible walls is outside the scope of this project, but minimally, the option we did analyze demonstrated that future I-405 widening projects can be designed and constructed without demolition or reconstruction of Wall 05.85L-A.

Detailed descriptions of our compound stability analysis methodology and the results of our analyses are presented in Section 7.9 and Section 8.7, respectively, of this geotechnical report. Compound stability models showing FS for critical failures at the design section are provided in this appendix. Slope/W reports are provided in Appendix K.

Appendix E.1 - Wall 05.85L-A
Plan, Profile and Sections



PLAN - WALL 05.85L-A



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS, SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

REFLECTIVE ELEVATION - WALL 05.85L-A

DATUM (NAVD) 88

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Washington State Department of Transportation

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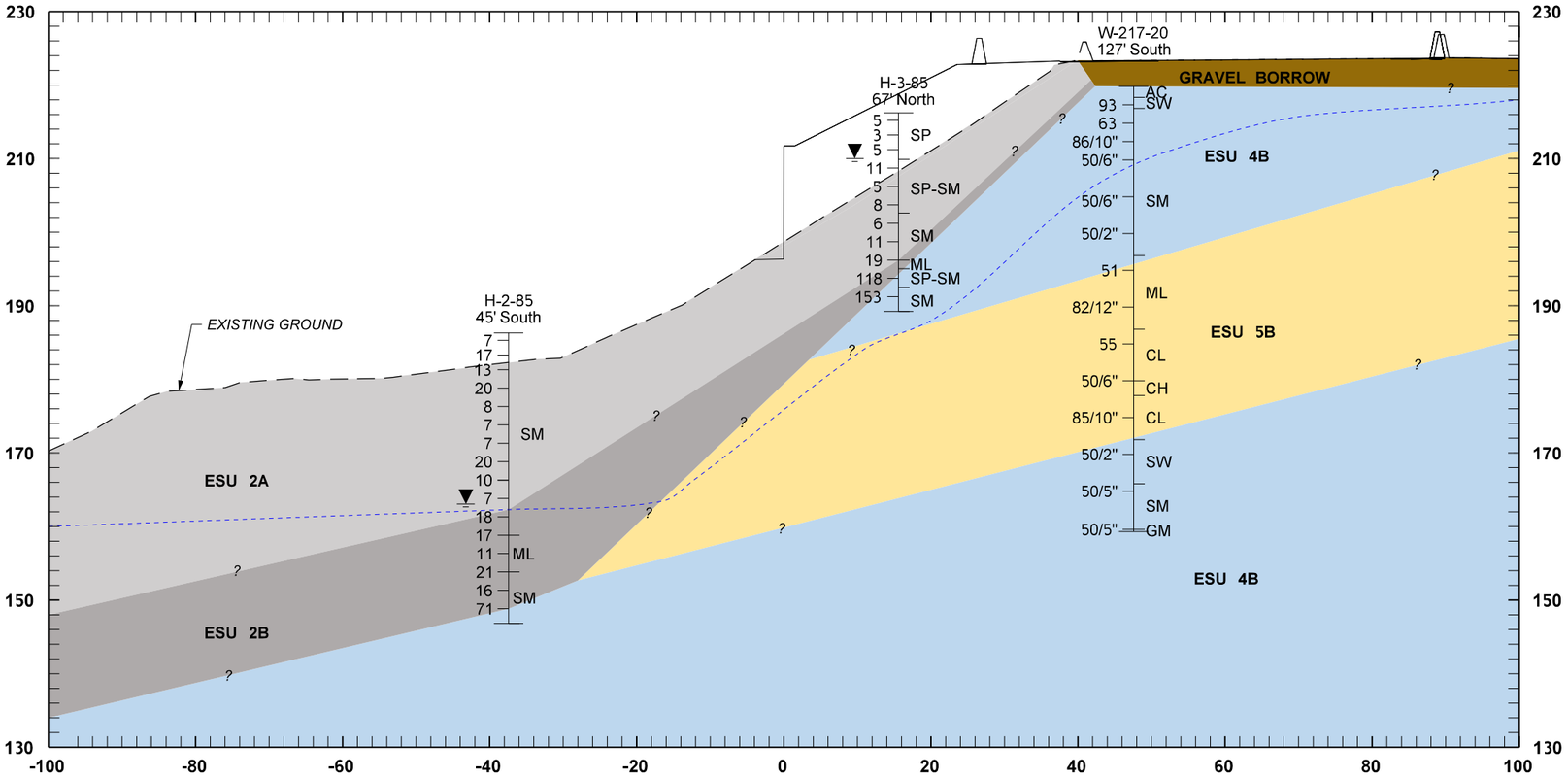
wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN AND ELEVATION WALL 05.85L-A

PLAN REF NO

SHEET 1 OF 1 SHEETS



WALL 05.85L-A STATION 1+90

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

WALL 05.85L-A
DESIGN SECTION AT STA. 1+90

PLAN REF NO

SHEET 1 OF 1 SHEETS

Appendix E.2 - Wall 05.85L-A ESU Soil Property Calculations

ESU	Description	Total No. of Samples [b]	USCS [c]	Fines [d] (%)	Plasticity Index, PI [e] (%)	Raw N (bpf)	N_{60} [f] (bpf)		$(N_1)_{60}$ [f] (bpf)		Total Unit Weight [g] (pcf)		Effective Friction Angle, ϕ' [h] (deg)		Fully Softened ϕ' [i] (deg)	Effective c' [j] (psf)	Residual ϕ' [k] (deg)	Residual Shear Strength, Sr (psf)	Undrained Shear Strength, Su (psf)	
				Value	Value	Value	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	COV [a]					Value	COV
1A	Loose to Medium Dense Coarse-Grained Fill	7	SP-SM	8	-	6	4	47%	7	44%	110	7%	34	6%	-	-	-	-	-	-
2A	Very Loose to Loose Sand/Gravel	17	SM	20	-	9	7	52%	10	54%	110	7%	32	7%	-	-	-	-	-	-
2B	Medium Dense Sand/Gravel	6	SM	40	-	17	16	20%	14	22%	110	2%	32	3%	-	-	-	497	-	-
4B	Dense to Very Dense Sand/Gravel	16	SM	18	-	148	108	24%	111	25%	130	2%	43	3%	-	-	-	-	-	-
5B	Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	5	ML/CL	82	20	76	108	32%	99	29%	130	2%	43	3%	-	-	-	-	-	-

Notes:

a. Coefficient of Variation (COV) percentage calculated to verify the variability and reliability of sample data within ESU (WSDOT GDM Section 5.11.2 (2015)). Calculated COV percentage compared to ranges presented in Table 52 (Sabatini et al. 2002) (below).

b. Number of samples excludes outliers.

c. Predominant USCS classification of all samples in ESU. Sandstone, where encountered, denoted as (SS).

d. Fines content percentage calculated as the geometric mean of all samples, whose values were determined through lab testing or estimated from field classification.

e. For coarse-grained ESUs, the plasticity index was estimated on the fine-grained portion of the soil. For fine-grained ESUs, if lab data is limited, the plasticity index may not be representative of the overall soil unit.

f. Corrected blow counts (N_{60} and $(N_1)_{60}$) were calculated following WSDOT GDM Section 5.5 (2015).

g. Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Unit weight data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.

h. Design friction angles were selected by considering fines content. Friction angle data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.

i. Where applicable, fully softened friction angle was estimated following WSDOT GDM, Figure 5-7 (After Stark and Hussain, 2013).

j. Where applicable, effective cohesion was calculated using Equations 6 through 8 in the WOOD Geotechnical SPM.

k. Where applicable, residual friction angle (to be used for slope stability evaluation) was estimated following WSDOT GDM, Figure 5-5 (After NAVFAC, 1971).

Measured or interpreted parameter value	Coefficient of Variation, V (%)
Unit weight, γ	3 to 7 %
Buoyant unit weight, γ_b	0 to 10 %
Effective stress friction angle, ϕ'	2 to 13 %
Undrained shear strength, s_u	13 to 40 %
Undrained strength ratio (s_u/σ_v')	5 to 15 %
Compression index, C_c	10 to 37 %
Preconsolidation stress, σ_p'	10 to 35 %
Hydraulic conductivity of saturated clay, k	68 to 90 %
Hydraulic conductivity of partly-saturated clay, k	130 to 240 %
Coefficient of consolidation, c_v	33 to 68 %
Standard penetration blowcount, N	15 to 45 %
Electric cone penetration test, q_c	5 to 15 %
Mechanical cone penetration test, q_c	15 to 37 %
Vane shear test undrained strength, s_{uVST}	10 to 20 %

Source: Table 52 (Sabatini et al. 2002)

ESU Name:	ESU 1A - Loose to Medium Dense Coarse-Grained Fill

	N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
GeoMean:	6	4	7	8	-	34	29	110	-	-
Average:	6	5	8	10	-	34	29	110	-	-
St. Dev.:	2.7	2.2	3.5	-	-	1.9	1.9	8.2	-	-
COV:	0.45	0.47	0.44	-	-	0.05	0.06	0.07	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
H-1-85	199.59	4	3	5	18	-	33	28	95	-	-	SM	
H-1-85	197.59	8	6	10	18	-	36	31	110	-	-	SM	
H-2-85	185.09	7	5	9	15	-	35	30	110	-	-	SM	
H-3-85	214.99	5	4	6	4	-	34	29	110	-	-	SP	
H-3-85	212.99	3	2	4	4	-	32	27	105	-	-	SP	
H-3-85	210.99	5	4	7	4	-	34	29	120	-	-	SP	
H-3-85	208.49	11	9	14	5	-	37	32	117.5	-	-	SP-SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 1A - Loose to Medium Dense Coarse-Grained Fill

1. Check N160 COV is between 15 and 45%

Selected Design N160:	7
Coefficient of Variation (COV):	0.44

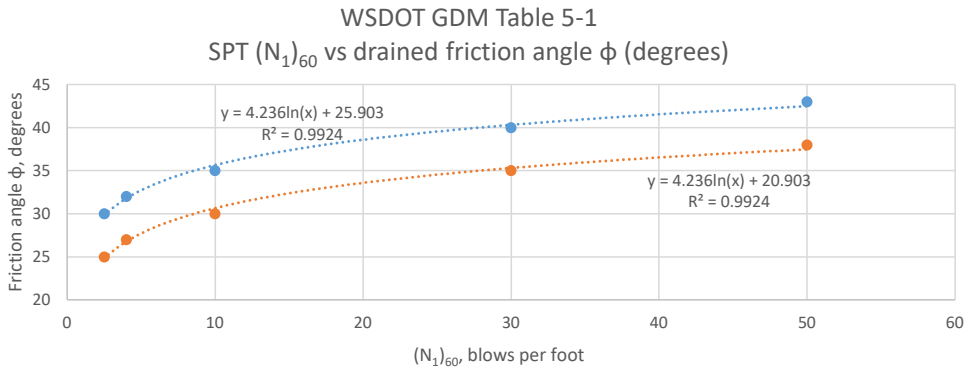
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



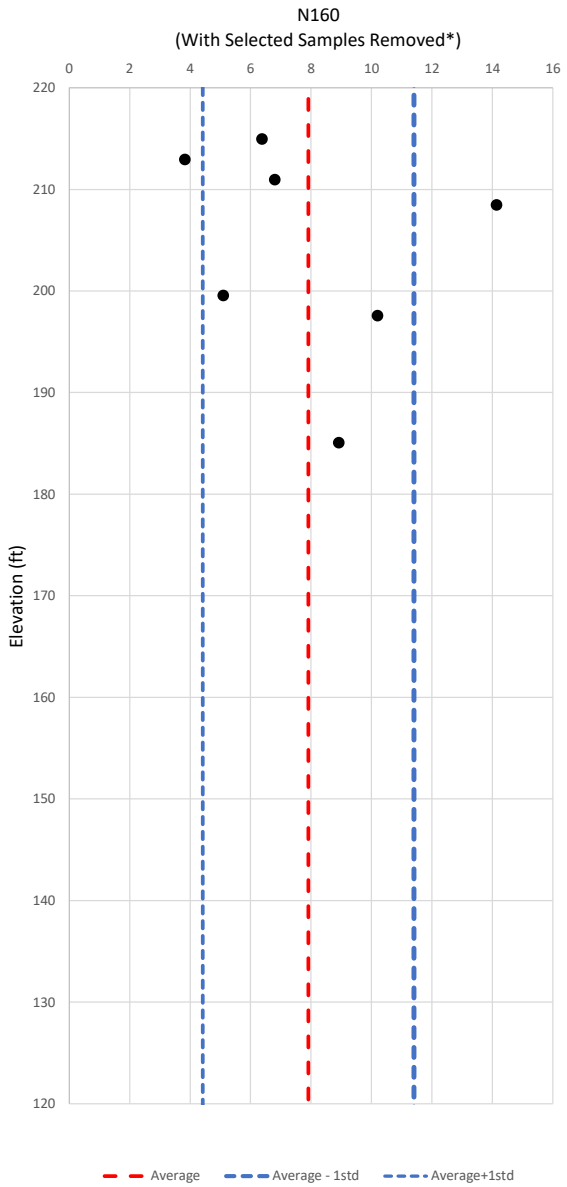
	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	34	29	32

ϕ' COV
0.06

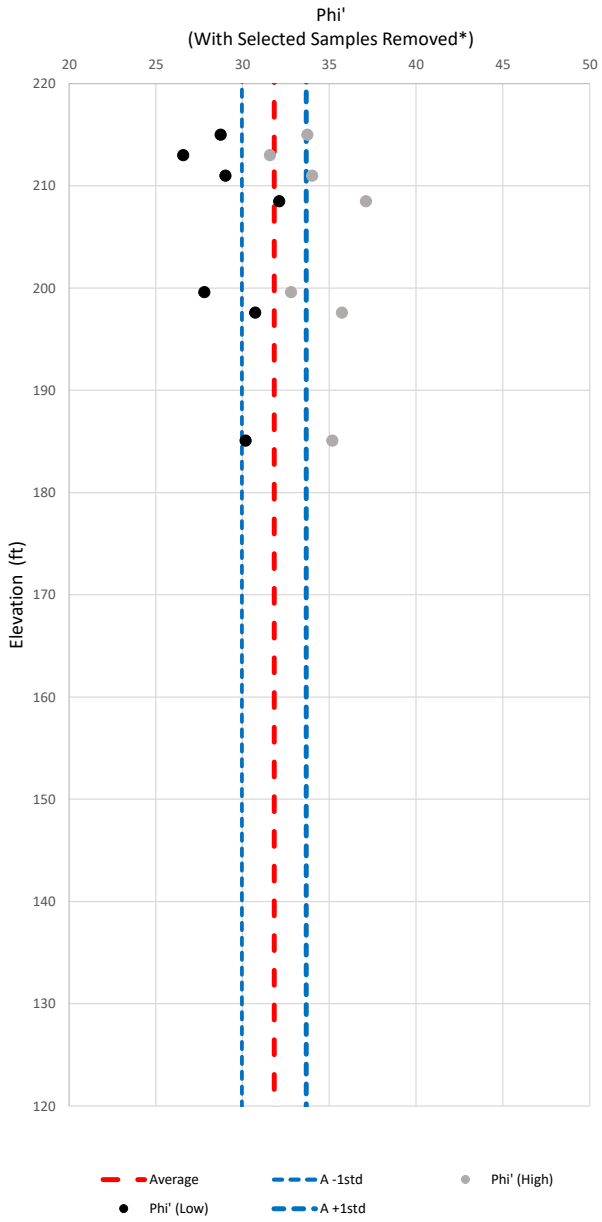
Selected Design Phi' (deg):	34
Notes on Selection:	The estimated fines content is 8% (geomean). The friction angle is interpolated based on fines content (phi' (high) at 5% fines, and phi' (low) at 30% fines).

Pick Representative USCS:	SP-SM	*Using Predominant USCS Classification
Pick Representative Unit Weight:	110	
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 7%.	

ESU 1A - Loose to Medium Dense Coarse-Grained Fill



*See sample table for explanation for removing specified samples if applicable



	ESU Name:	ESU 2A - Very Loose to Loose Sand/Gravel									
		N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	9	7	10	20	-	35	30	110	-	-
	Average:	10	8	11	21	-	36	31	110	-	-
	St. Dev.:	5.1	4.4	5.9	-	-	2.1	2.1	7.2	-	-
	COV:	0.53	0.52	0.54	-	-	0.06	0.07	0.07	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
H-1-85	195.59	3	2	4	22	-	32	27	90	-	-	SM	
H-1-85	193.09	4	3	5	28	-	33	28	95	-	-	SM	
H-1-85	190.59	10	9	12	18	-	36	31	110	-	-	SM	
H-1-85	188.09	9	8	10	31	-	36	31	110	-	-	SM	
H-2-85	183.09	17	13	22	24	-	39	34	115	-	-	SM	
H-2-85	181.09	13	10	18	15	-	38	33	115	-	-	SM	
H-2-85	178.59	20	16	23	18	-	39	34	115	-	-	SM	
H-2-85	176.09	8	7	9	16	-	35	30	110	-	-	SM	
H-2-85	173.59	7	6	7	30	-	34	29	110	-	-	SM	
H-2-85	171.09	7	7	8	22	-	34	29	110	-	-	SM	
H-2-85	168.59	20	19	20	25	-	39	34	115	-	-	SM	
H-2-85	166.09	10	10	9	27	-	35	30	110	-	-	SM	
H-2-85	163.59	7	7	6	24	-	34	29	100	-	-	SM	
H-3-85	205.99	5	4	6	10	-	34	29	105	-	-	SP-SM	
H-3-85	203.49	8	7	9	12	-	35	30	115	-	-	SP-SM	
H-3-85	200.99	6	6	7	12	-	34	29	110	-	-	SM	
H-3-85	198.49	11	10	11	19	-	36	31	110	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 2A - Very Loose to Loose Sand/Gravel

1. Check N160 COV is between 15 and 45%

Selected Design N160:	10
Coefficient of Variation (COV):	0.54

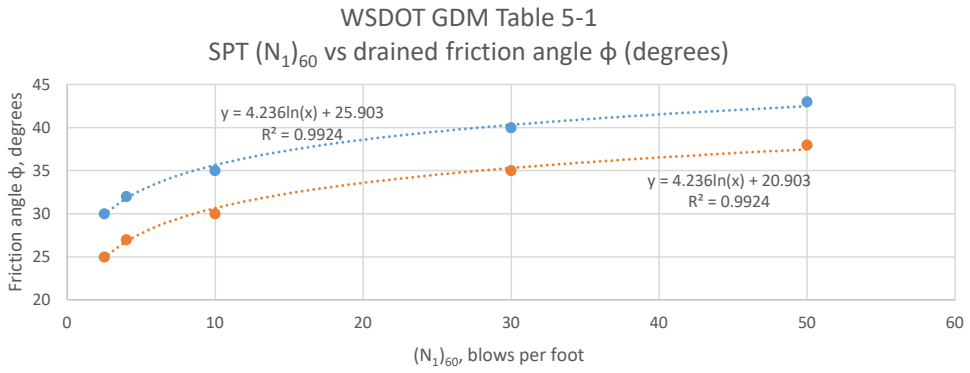
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	35	30	33

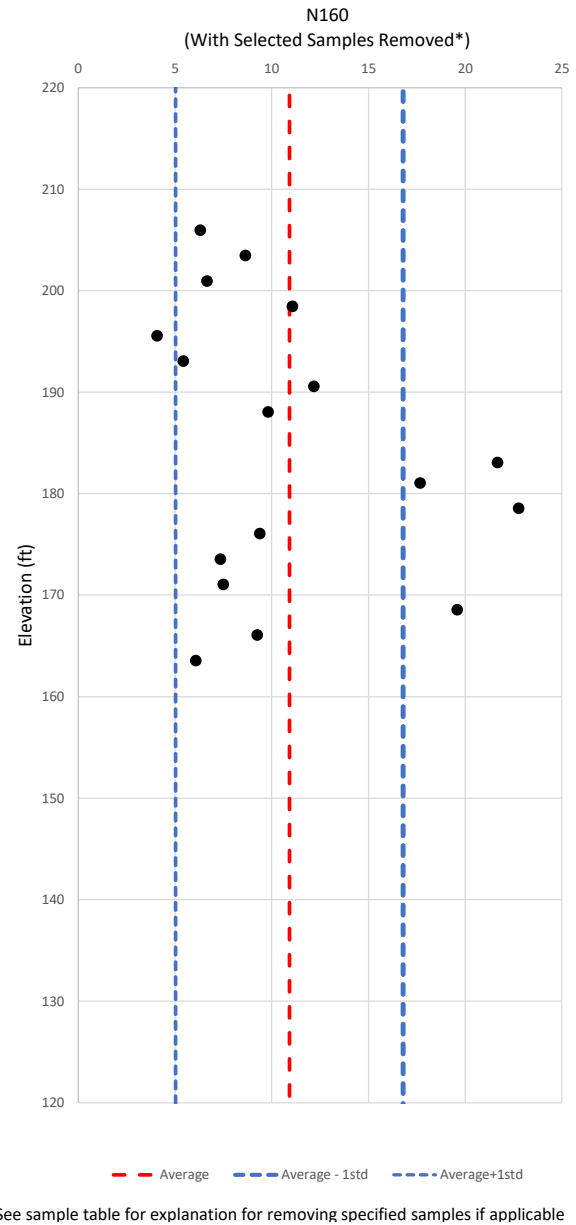
ϕ' COV
0.07

Selected Design Phi' (deg):	32
Notes on Selection:	The estimated fines content is 20% (geomean). The friction angle is interpolated based on fines content (phi' (high) at 5% fines, and phi' (low) at 30% fines).

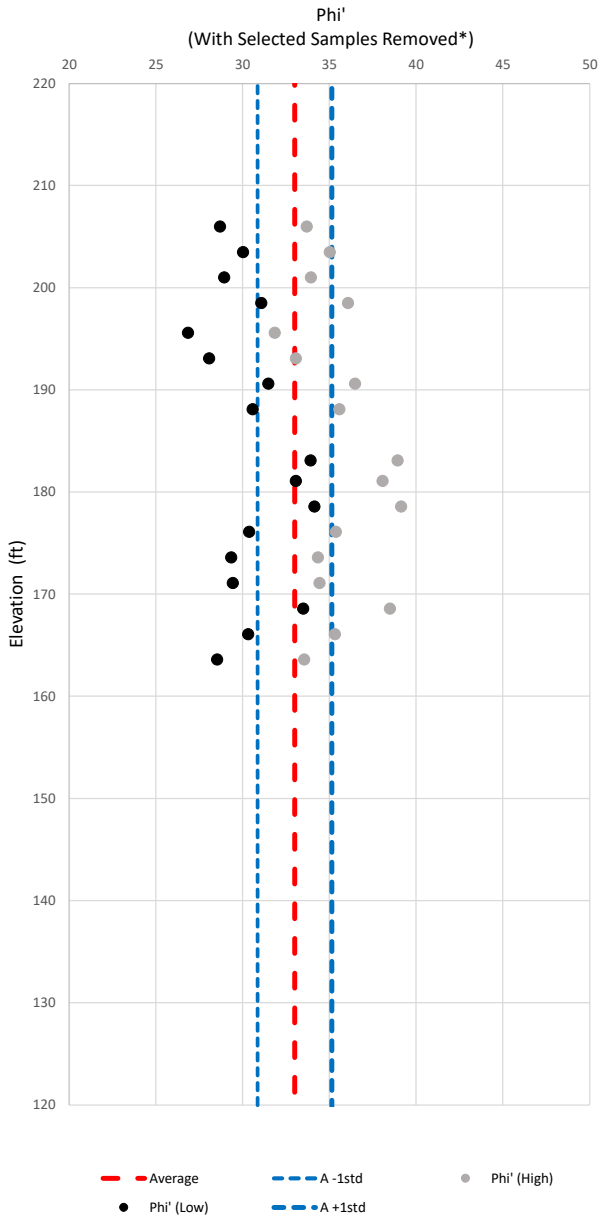
Pick Representative USCS:	SM
Pick Representative Unit Weight:	110
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 7%.

*Using Predominant USCS Classification

ESU 2A - Very Loose to Loose Sand/Gravel



*See sample table for explanation for removing specified samples if applicable



ESU Name:	ESU 2B - Medium Dense Sand/Gravel									
	N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
GeoMean:	17	16	14	40	-	37	32	110	-	497
Average:	17	17	15	44	-	37	32	110	-	514
St. Dev.:	3.4	3.3	3.2	-	-	1.0	1.0	2.0	-	-
COV:	0.20	0.20	0.22	-	-	0.03	0.03	0.02	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
H-2-85	161.09	18	17	15	26	-	37	32	110	-	527	SM	
H-2-85	158.59	17	16	14	60	-	37	32	110	-	538	ML	
H-2-85	156.09	11	11	9	51	-	35	30	110	-	331	ML	
H-2-85	153.59	21	21	18	33	-	38	33	115	-	735	SM	
H-2-85	151.09	16	16	13	22	-	37	32	110	-	441	SM	
H-3-85	195.99	19	18	18	70	-	38	33	110	-	-	ML	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 2B - Medium Dense Sand/Gravel

1. Check N160 COV is between 15 and 45%

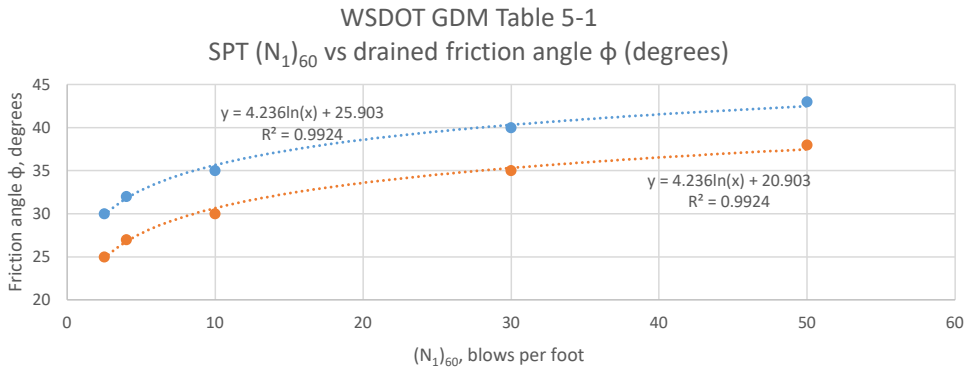
Selected Design N160:	14
Coefficient of Variation (COV):	0.22

* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation
* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	37	32	35

ϕ' COV
0.03

Selected Design Phi' (deg):	32
Notes on Selection:	The estimated fines content is 40% (geomean). The high fines content supports the use of the lower bound of the friction angle range.

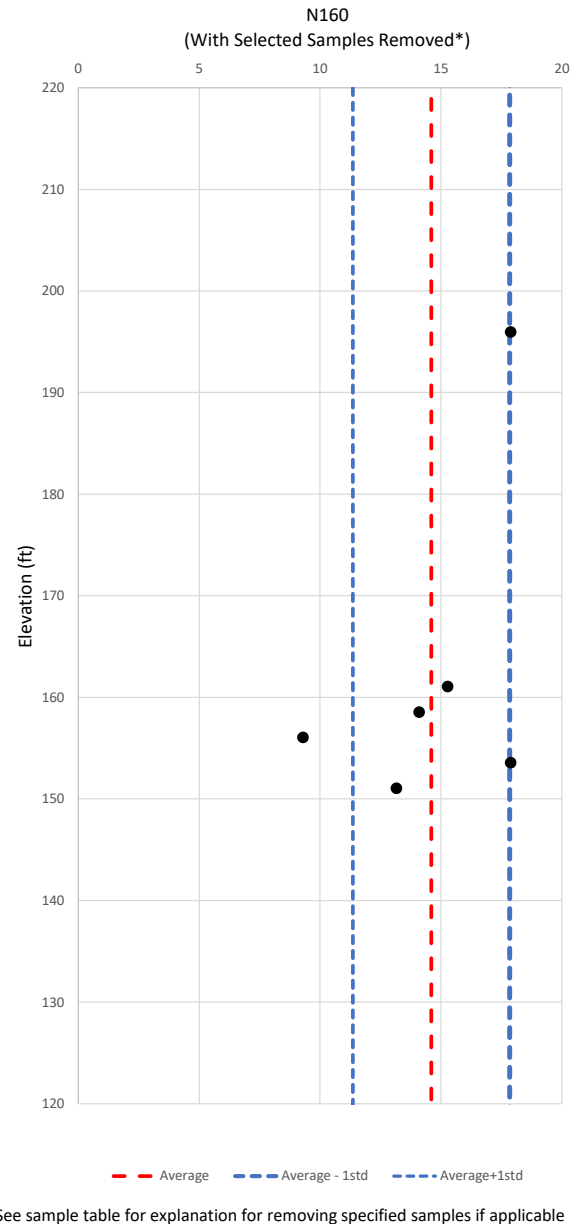
Pick Representative USCS:	SM
Pick Representative Unit Weight:	110
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 2%.

*Using Predominant USCS Classification

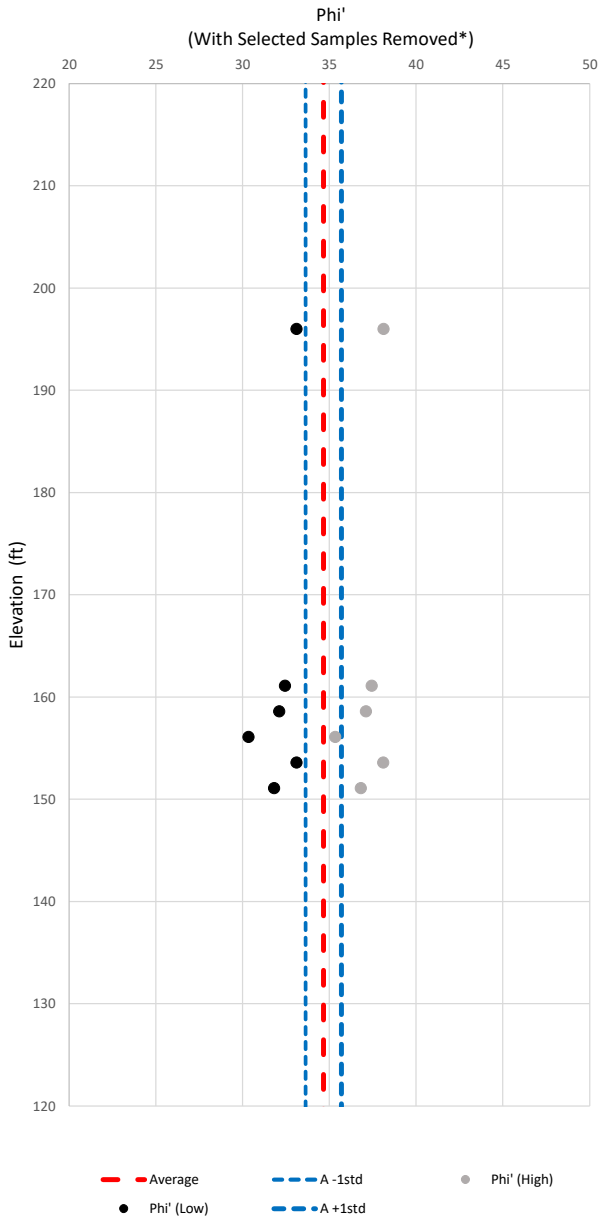
4. Residual Strength (psf):

Sr Selected:	497
Notes on Selection:	Individual sample residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20.

ESU 2B - Medium Dense Sand/Gravel



*See sample table for explanation for removing specified samples if applicable



	ESU Name:	ESU 4B - Dense to Very Dense Sand/Gravel									
		N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	148	108	111	18	-	46	41	130	-	-
	Average:	174	111	114	23	-	46	41	130	-	-
	St. Dev.:	106.1	26.1	28.3	-	-	1.1	1.1	3.0	-	-
	COV:	0.61	0.24	0.25	-	-	0.02	0.03	0.02	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-217-20	217.1	93	102	167	45	-	48	43	130	-	-	SM	
W-217-20	214.6	63	74	101	30	-	45	40	130	-	-	SM	
W-217-20	212.1	111	117	144	37	-	47	42	130	-	-	SM	
W-217-20	209.6	100	125	142	40	-	47	42	130	-	-	SM	
W-217-20	204.6	100	139	148	40	-	47	42	130	-	-	SM	
W-217-20	199.6	300	139	141	40	-	47	42	130	-	-	SM	
W-217-20	169.6	300	147	124	11	-	46	41	140	-	-	SW	
W-217-20	164.6	120	147	121	30	-	46	41	130	-	-	SM	
W-217-20	159.6	120	147	119	30	-	46	41	130	-	-	GM	
H-1-85	185.59	138	95	102	8	-	46	41	130	-	-	SP-SM	
H-1-85	183.09	297	95	97	9	-	45	40	130	-	-	SP-SM	
H-1-85	180.59	400	95	93	7	-	45	40	135	-	-	SP-SM	
H-1-85	175.59	300	95	90	6	-	45	40	135	-	-	SP-SM	
H-2-85	148.59	71	71	63	7	-	43	38	135	-	-	SP-SM	
H-3-85	193.49	118	95	91	11	-	45	40	130	-	-	SP-SM	
H-3-85	190.99	153	95	88	11	-	45	40	130	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 4B - Dense to Very Dense Sand/Gravel

1. Check N160 COV is between 15 and 45%

Selected Design N160:	111
Coefficient of Variation (COV):	0.25

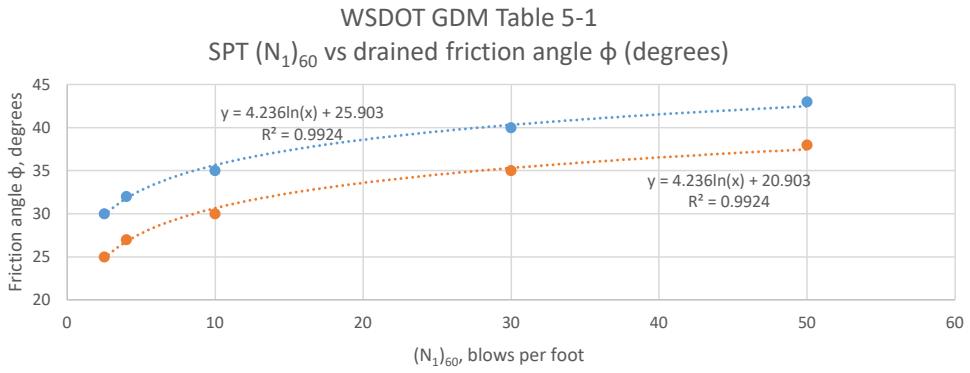
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	46	41	43

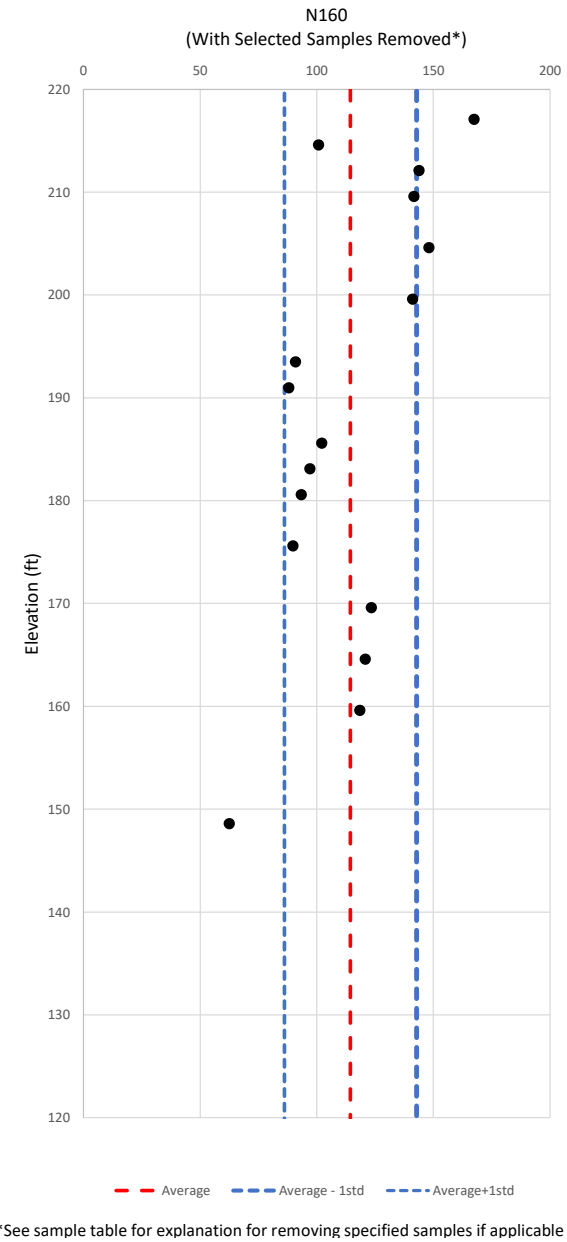
ϕ' COV
0.03

Selected Design Phi' (deg):	43
Notes on Selection:	The estimated geomean fines content is 18% (geomean). The friction angle is taken as the upper bound and capped at 43 degrees for glacially consolidated material with fines content less than 70%.

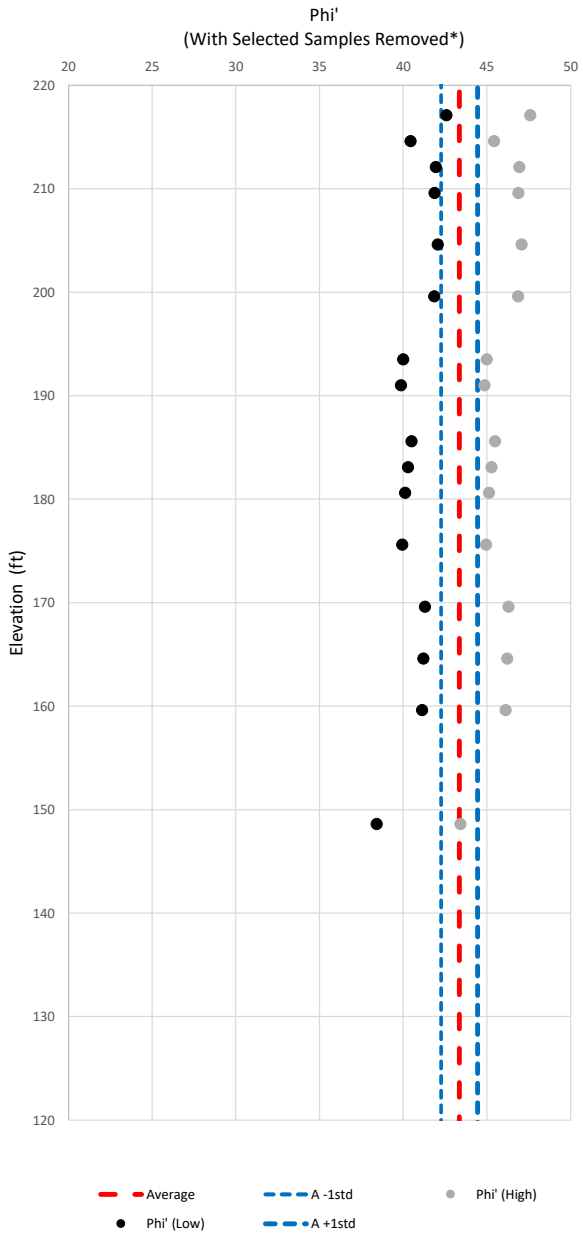
Pick Representative USCS:	SM
Pick Representative Unit Weight:	130
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 2%.

*Using Predominant USCS Classification

ESU 4B - Dense to Very Dense Sand/Gravel



*See sample table for explanation for removing specified samples if applicable



	ESU Name:	ESU 5B - Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt									
		N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	76	108	99	82	20	45	40	130	-	-
	Average:	80	113	102	83	21	45	40	130	-	-
	St. Dev.:	26.3	35.8	29.2	-	-	1.3	1.3	2.2	-	-
	COV:	0.33	0.32	0.29	-	-	0.03	0.03	0.02	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-217-20	194.6	51	71	69	90	18	44	39	130	-	-	ML	
W-217-20	189.6	82	120	113	90	-	46	41	130	-	-	ML	
W-217-20	184.6	55	81	73	92	16	44	39	130	-	-	CL	
W-217-20	179.6	100	147	130	73	28	47	42	125	-	-	CH	
W-217-20	174.6	110	147	127	70	-	46	41	130	-	-	CL	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 5B - Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

1. Check N160 COV is between 15 and 45%

Selected Design N160:	99
Coefficient of Variation (COV):	0.29

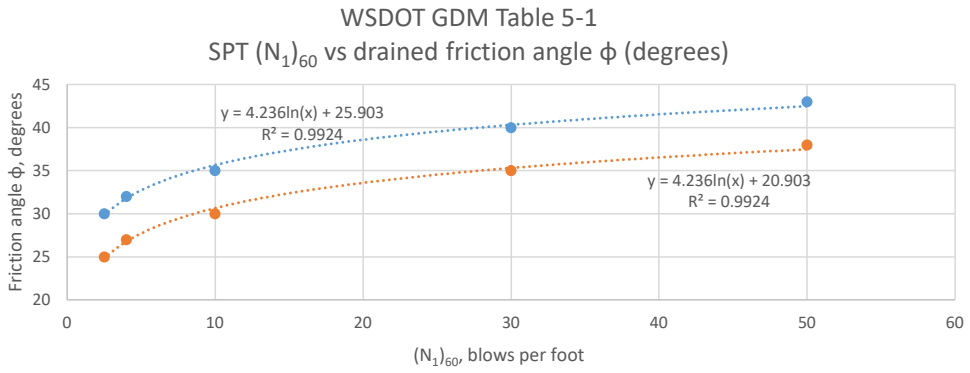
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	45	40	43

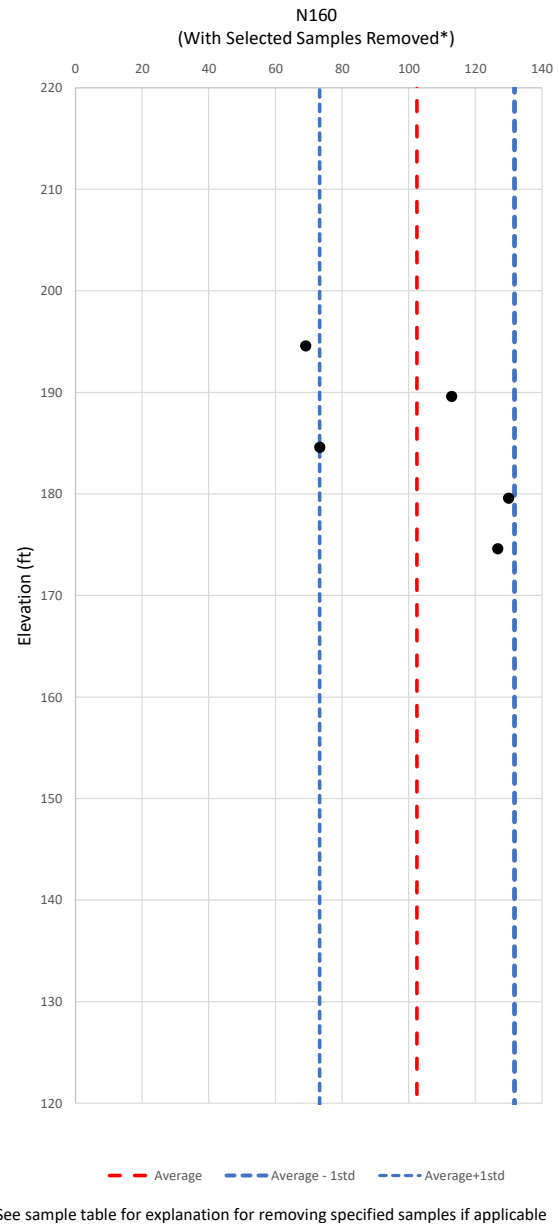
ϕ' COV
0.03

Selected Design Phi' (deg):	43
Notes on Selection:	The estimated geomean fines content is 82% (geomean). The friction angle is taken as the average of upper bound and lower bound and capped at 43 degrees for glacially consolidated material with fines content more than 70%.

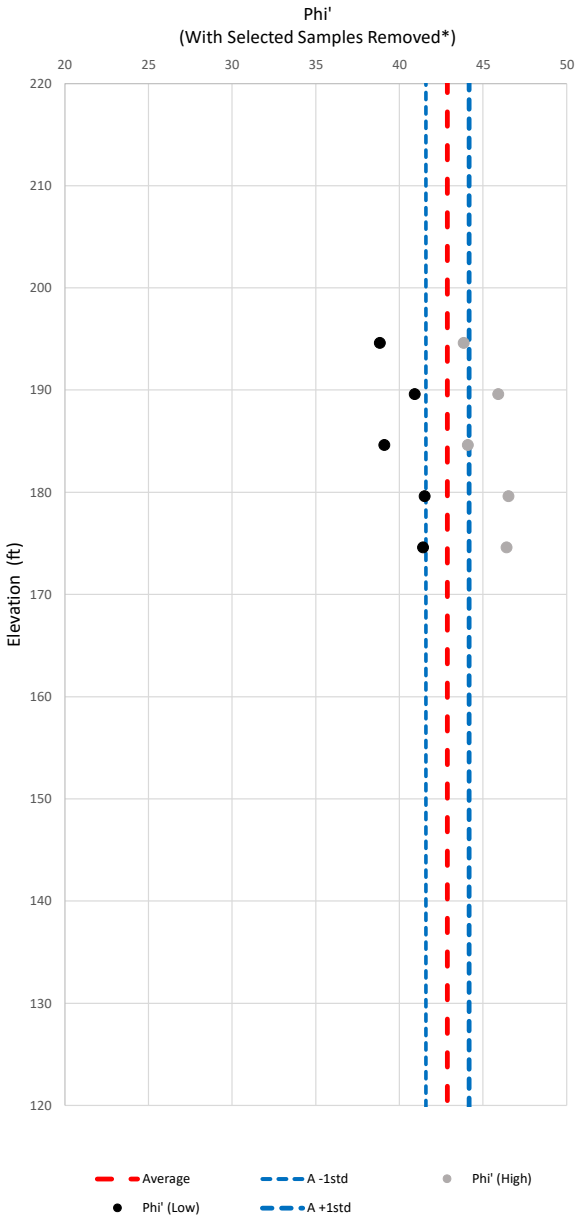
Pick Representative USCS:	ML/CL
Pick Representative Unit Weight:	130
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 2%.

*Using Predominant USCS Classification

ESU 5B - Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt



*See sample table for explanation for removing specified samples if applicable



One of the primary shortcomings of the Mononobe-Okabe method is that it cannot consider the effect of cohesion in the backfill on the seismic active earth pressure. Even relatively small amounts of cohesion in the backfill can significantly reduce the seismic active earth pressure. Sources of cohesion in backfill soils include both true cohesion due to inter-particle bonding and apparent cohesion due to capillary forces in the backfill. The influence of cohesion on the seismic active earth pressure is a function of the normalizing parameter $c\gamma/H$, where γ is the unit weight of the backfill soil. Figure 11-14 presents a plot of the seismic active earth pressure coefficient, k_{AE}, as a function of the normalizing parameter $c/\gamma H$ and the seismic coefficient, k_h, for a friction angle of 35° and for a uniform level backfill. An Appendix in NCHRP Report 611 presents additional plots for friction angles of 30° and 40°.

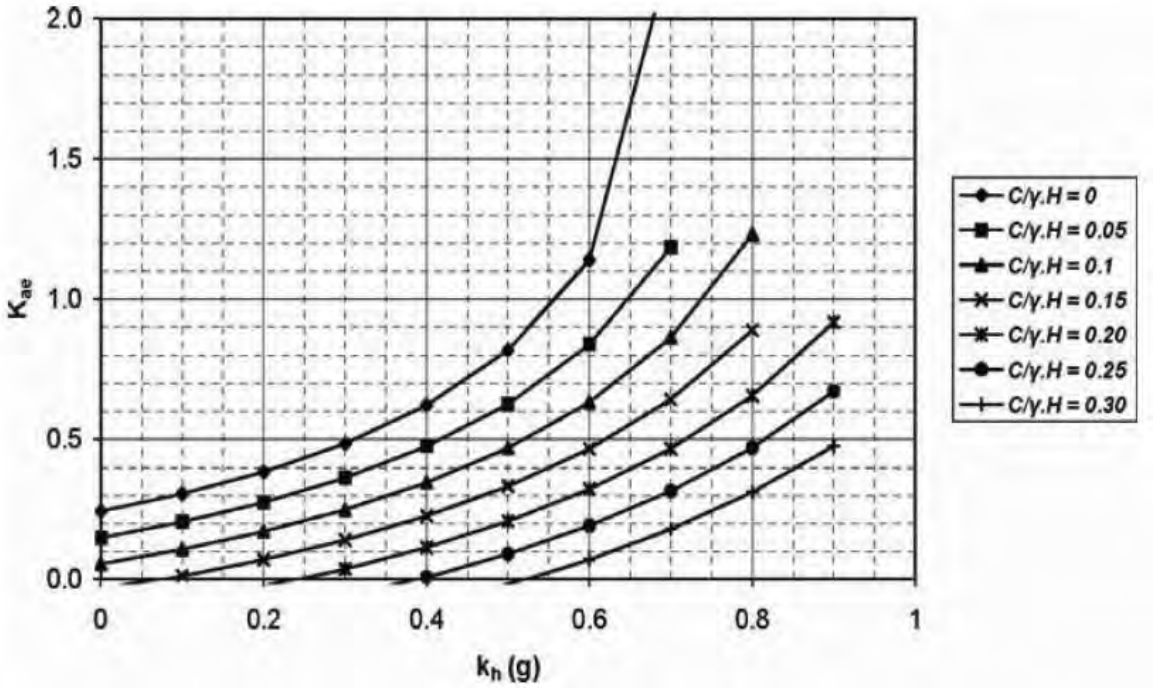


Figure 11-14 Effect of cohesion on the seismic active earth pressure coefficient for $\phi = 35°$ (NCHRP, 2008)

NCHRP Report 611 provides recommendations for the maximum amount of apparent cohesion that should be assumed for backfill soil as a function of the fines content of the soil. These recommendations are presented in Table 11-2.

TABLE 11-2 MAXIMUM AMOUNT OF APPARENT COHESION THAT SHOULD BE ASSUMED FOR BACKFILL SOILS (NCHRP, 2008)

% (by weight) passing #200 sieve	maximum apparent cohesion

5 - 15	50 psf
15 - 25	100 psf
25-50	200 psf

ESU 2A (FC=20%)

ESU 2B (FC=40%)

11.3.3 Log Spiral Earth Pressure Theory

The Mononobe-Okabe and Trial Wedge methods for calculating earth pressure assume that the failure surface in the backfill is planar. It has been long recognized that when there is a significant soil-wall friction angle, the assumption of the planar failure surface is incorrect. Instead, in a homogeneous soil a logarithmic surface gives the critical values for the active and passive earth pressure in a limit equilibrium analysis. Note, however, that when there is no wall friction the logarithmic surface degenerates to a planar surface. As illustrated in Figure 11-15, or the active case the difference between the critical log spiral surface and the critical planar surface is small enough that it can be ignored, even when there is wall friction. However, as illustrated in Figure 11-15, the critical log spiral surface for the passive case differs significantly from the critical planar surface when the wall friction angle is more than one-third the value of the backfill friction angle. In these cases it is essential to consider the logarithmic surface: failure to do so can result in an unconservative assessment of the seismic passive earth pressure.

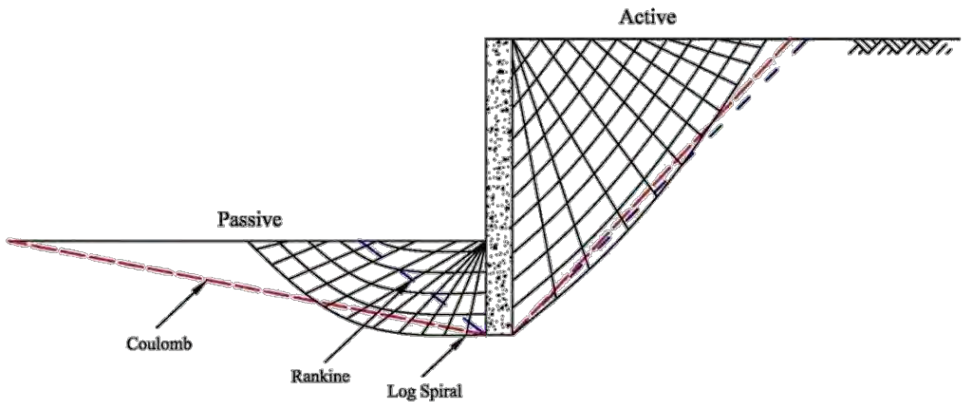


Figure 11-15 Critical Log Spiral Surfaces Compared to Planar Critical Surfaces

The log spiral method can be used to evaluate seismic passive earth pressures accounting for backfill friction and cohesion, soil-wall interface friction angle, and backslope angle. Shamsabadi et al. (2007) describe the general method that can be used to do this. The soil-wall interface friction angle is a key parameter in this approach. The soil-wall interface friction angle for static loading is often assumed to

The coefficient of consolidation, c_v, should be determined from the results of one-dimensional consolidation tests. The variability in laboratory determination of c_v results should be considered in the final selection of the value of c_v to be used for design.

Where evaluation of elastic settlement is critical to the design of the foundation or selection of the foundation type, in-situ methods such as PMT or *DMT* for evaluating the modulus of the stratum should be used.

A profile of σ_p', or OCR = σ_p'/σ_o', with depth should be developed for the site for design applications where the stress history could have a significant impact on the design properties selected and the performance of the foundation. As with consolidation properties, an upper and lower bound profile should be developed based on laboratory tests and plotted with a profile based on particular in-situ test(s), if used. It is particularly important to accurately compute preconsolidation stress values for relatively shallow depths where in-situ effective stresses are low. An underestimation of the preconsolidation stress at shallow depths will result in overly conservative estimates of settlement for shallow soil layers.

Due to the numerous simplifying assumptions associated with conventional consolidation theory, on which the coefficient of consolidation is based, it is unlikely that even the best estimates of c_v from high-quality laboratory tests will result in predictions of time rate of settlement in the field that are significantly better than a prediction within one order of magnitude. In general, the in-situ value of c_v is larger than the value measured in the laboratory test. Therefore, a rational approach is to select average, upper, and lower bound values for the appropriate stress range of concern for the design application. These values should be compared to values obtained from previous work performed in the same soil deposit. Under the best-case conditions, these values should be compared to values computed from measurements of excess pore pressures or settlement rates during construction of other structures.

CPTu tests in which the pore pressure dissipation rate is measured may be used to estimate the field coefficient of consolidation.

For preliminary analyses or where accurate prediction of settlement is not critical, values obtained from correlations to index properties presented in Sabatini et al. (2002) may be used.

For preliminary design or for final design where the prediction of deformation is not critical to structure performance, i.e., the structure design can tolerate the potential inaccuracies inherent in the correlations. The elastic properties (E_s, ν) of a soil may be estimated from empirical relationships presented in Table C10.4.6.3-1.

The specific definition of E_s is not always consistent for the various correlations and methods of in-situ measurement. See Sabatini et al. (2002) for additional details regarding the definition and determination of E_s.

An alternative method of evaluating the equivalent elastic modulus using measured shear wave velocities is presented in Sabatini et al. (2002).

Table C10.4.6.3-1—Elastic Constants of Various Soils (modified after U.S. Department of the Navy, 1982; Bowles, 1988)

Soil Type	Typical Range of Young's Modulus Values, E_s (ksi)	Poisson's Ratio, ν (dim)
Clay:		
Soft sensitive		
Medium stiff to stiff	0.347–2.08	0.4–0.5 (undrained)
	2.08–6.94	
Very stiff	6.94–13.89	
Loess	2.08–8.33	0.1–0.3
Silt	0.278–2.78	0.3–0.35
Fine Sand:		
Loose	1.11–1.67	0.25
Medium dense	1.67–2.78	
Dense	2.78–4.17	
Sand:		
Loose	1.39–4.17	0.20–0.36
Medium dense	4.17–6.94	
Dense	6.94–11.11	0.30–0.40
Gravel:		
Loose	4.17–11.11	0.20–0.35
Medium dense	11.11–13.89	
Dense	13.89–27.78	0.30–0.40

Estimating E_s from *SPT N* Value	
Soil Type	E_s (ksi)
Silts, sandy silts, slightly cohesive mixtures	0.056 $N_{1,60}$
Clean fine to medium sands and slightly silty sands	0.097 $N_{1,60}$
Coarse sands and sands with little gravel	0.139 $N_{1,60}$
Sandy gravel and gravels	0.167 $N_{1,60}$
Estimating E_s from q_c (static cone resistance)	
Sandy soils	$0.028q_c$

ESU 2A Very Loose to Loose Sand/ Gravel
Es = 3.7 ksi = 530 ksf
Poisson Ratio = 0.33

The modulus of elasticity for normally consolidated granular soils tends to increase with depth. An alternative method of defining the soil modulus for granular soils is to assume that it increases linearly with depth starting at zero at the ground surface in accordance with the following equation:

$$E_s = nh \times z \quad \text{(C10.4.6.3-1)}$$

where:

Wall 05.85L-A Soil Saturated Hydraulic Conductivity Estimates

References:

- Washington State Department of Transportation (WSDOT). Highway Runoff Manual. M31-16.05. April 2019
- Massmann, J. W. 2003. Implementation of Infiltration Ponds Research, WA-RD 578.1.
- Allen, T.M. 2017. Stormwater Infiltration in Highway Embankments – Saturated Hydraulic Conductivity Estimation for Uncompacted and Compacted Soils, WSDOT Research Report WARD 872-1.
- Allen, T.M. 2018. Stormwater Infiltration in Highway Embankments – Saturated Hydraulic Conductivity Estimation for Natural Low Plasticity Silts, WSDOT Research Report WA-RD 872-2.

WSDOT research has been conducted to investigate the most promising saturated hydraulic conductivity (K_{sat}) predictive equations to assess and improve K_{sat} prediction accuracy using soils commonly encountered in WSDOT projects (Massmann 2003; Allen 2017, 2018). Based on that research, if a grain size based correlation is used, K_{sat} on WSDOT projects should be estimated using the optimized Slichter Equation as developed in Allen (2017).

Soil saturated hydraulic conductivity K_{sat} was estimated using the procedures outlined in Section 4D-4.1 of the Washington State Department of Transportation (WSDOT) Highway Runoff Manual (April 2019 updates) to estimate K_{sat} of site soil using correlations between Ksat and grain-size distribution data.

We used Equation 4D-3 in the HRM to estimate Ksat for soils based on grain-size. Equation 4D-3 is:

$$K_{sat} = 21.2\,\eta^{3.5}\,{d_{10}}^{1.75}$$

Where:
K_{sat} = saturated hydraulic conductivity (centimeters per second [cm/sec])
η = porosity
d_{10} = grain size (millimeters [mm]) at which 10 percent of the material passes by weight

For natural soil deposits, porosity can be estimated using equation 4D-4 in the HRM if measured porosities or void ratios are not available:

$$\eta = 0.4\left({d_{10}}^{-0.08}\right)\left({C_u}^{-0.1}\right)\left(F_{cp}\right) + 0.0015\left(PI\right)$$

Where:
C_u = uniformity coefficient (d_{60}/d_{10})
d_{60} = grain size (mm) at which 60 percent of the material passes by weight

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F_{cp} = compaction factor for porosity (set equal to 1.0 for loose or un-compacted soil)
PI = plasticity index

Example Calculations

Determine:

- Saturated hydraulic conductivity (K_{sat})

Given:

The following seive analysis results for consecutive samples from borings H-1-85, H-2-85, and H-3-85 which are described as being from with in the same Engineering Soil Unit ESU 2A:

ESU 2A					
Boring	Sample Number	Sample Depth (feet below groundsurface)	Soil Type	D10 (mm)	D60 (mm)
H-1-85	P-3	5 to 7	SM	0.040	0.58
H-1-85	P-4	7.5 to 9.5	SM	0.035	0.28
H-1-85	P-5	10 to 12	SM	0.047	1.03
H-1-85	P-6	12.5 to 14.5	SM	0.044	0.16
H-2-85	P-2	3 to 5	SM	0.034	0.58
H-2-85	P-3	5 to 7	SM	0.058	0.61
H-2-85	P-4	7.5 to 9.5	SM	0.051	0.53
H-2-85	P-5	10 to 12	SM	0.055	0.69
H-2-85	P-7	15 to 17	SM	0.050	0.29
H-2-85	P-8	17.5 to 19.5	SM	0.030	0.55
H-2-85	P-9	20 to 22	SM	0.020	0.86
H-2-85	P-10	22.5 to 24.5	SM	0.035	0.55
H-3-85	P-6	12.5 to 14.5	SP-SM	0.067	1.03
H-3-85	P-8	17.5 to 19.5	SM	0.057	0.28

The following seive analysis results for consecutive samples from boring H-2-85 which are described as being from with in the same Engineering Soil Unit ESU 2B:

ESU 2B					
Boring	Sample Number	Sample Depth (feet below groundsurface)	USGS	D10 (mm)	D60 (mm)
H-2-85	P-11	25 to 27	SM	0.027	0.68
H-2-85	P-12	27.5 to 30	ML	0.003	0.08
H-2-85	P-13	30 to 32	ML	0.017	0.10
H-2-85	P-14	32.5 to 34.5	SM	0.042	0.15
H-2-85	P-15	35 to 37	SM	0.041	0.48
Average					

Solution:

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Find K_{sat} for sample P-3 in boring H-1-85 (other samples calculated similarly)

$d_{10} := 0.040\ mm$

$d_{60} := 0.58\ mm$

$C_u := \frac{d_{60}}{d_{10}} = 14.5$

$F_{cp} := 1.0$ (Natural site soil was deposited under alluvial conditions, has not been subjected to compaction and is not overconsolidated.)

$PI := 0.0$ (non-plastic soil)

$$\eta := 0.4 \cdot \left(\left(\frac{d_{10}}{mm}\right)^{-0.08}\right) \cdot \left(C_u{}^{-0.1}\right) \cdot \left(F_{cp}\right) + 0.0015 \cdot \left(PI\right) = 0.396$$

$$K_{sat} := 21.2 \cdot \left(\eta^{3.5}\right) \cdot \left(\left(\frac{d_{10}}{mm}\right)^{1.75}\right) = 3.0 \cdot 10^{-3}\ \frac{cm}{s}$$

$$K_{sat} := \frac{K_{sat}}{\left(2.54 \cdot 12\right)} = 9.7 \cdot 10^{-5}\ \frac{ft}{s}$$

Results:

The results of estimated K_{sat} values for site soil samples for which grain-size analyses were conducted are as follows:

Saturated hydraulic conductivity (Ks) for ESU 2A								
ESU 2A							WSDOT 2019 HRM Method	
Boring	Sample Number	Sample Depth (feet below groundsurface)	Soil Type	D10 (mm)	D60 (mm)	Porosity	Ksat (cm/s)	Ksat (ft/s)
H-1-85	**P-3**	**5 to 7**	**SM**	**0.040**	**0.58**	0.40	3.0E-03	9.7E-05
H-1-85	**P-4**	**7.5 to 9.5**	**SM**	**0.035**	**0.28**	0.43	3.1E-03	1.0E-04
H-1-85	**P-5**	**10 to 12**	**SM**	**0.047**	**1.03**	0.38	3.3E-03	1.1E-04
H-1-85	**P-6**	**12.5 to 14.5**	**SM**	**0.044**	**0.16**	0.45	5.6E-03	1.8E-04
H-2-85	**P-2**	**3 to 5**	**SM**	**0.034**	**0.58**	0.40	2.2E-03	7.2E-05
H-2-85	**P-3**	**5 to 7**	**SM**	**0.058**	**0.61**	0.40	5.7E-03	1.9E-04
H-2-85	**P-4**	**7.5 to 9.5**	**SM**	**0.051**	**0.53**	0.40	4.7E-03	1.6E-04
H-2-85	**P-5**	**10 to 12**	**SM**	**0.055**	**0.69**	0.39	5.0E-03	1.7E-04
H-2-85	**P-7**	**15 to 17**	**SM**	**0.050**	**0.29**	0.43	5.6E-03	1.9E-04
H-2-85	**P-8**	**17.5 to 19.5**	**SM**	**0.030**	**0.55**	0.40	1.8E-03	5.9E-05
H-2-85	**P-9**	**20 to 22**	**SM**	**0.020**	**0.86**	0.38	7.2E-04	2.3E-05
H-2-85	**P-10**	**22.5 to 24.5**	**SM**	**0.035**	**0.55**	0.40	2.4E-03	7.7E-05
H-3-85	**P-6**	**12.5 to 14.5**	**SP-SM**	**0.067**	**1.03**	0.38	6.2E-03	2.0E-04
H-3-85	**P-8**	**17.5 to 19.5**	**SM**	**0.057**	**0.28**	0.43	7.4E-03	2.4E-04
Average							4.1E-03	1.3E-04
Geometric Mean							3.5E-03	1.1E-04

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Saturated hydraulic conductivity (Ks) for ESU 2B								
ESU 2B							WSDOT 2019 HRM Method	
Boring	Sample Number	Sample Depth (feet below groundsurface)	USGS	D10 (mm)	D60 (mm)	Porosity	Ksat (cm/s)	Ksat (ft/s)
H-2-85	**P-11**	**25 to 27**	**SM**	**0.027**	**0.68**	0.39	1.3E-03	4.4E-05
H-2-85	**P-12**	**27.5 to 30**	**ML**	**0.003**	**0.08**	0.46	4.0E-05	1.3E-06
H-2-85	**P-13**	**30 to 32**	**ML**	**0.017**	**0.10**	0.46	1.2E-03	3.9E-05
H-2-85	**P-14**	**32.5 to 34.5**	**SM**	**0.042**	**0.15**	0.45	5.2E-03	1.7E-04
H-2-85	**P-15**	**35 to 37**	**SM**	**0.041**	**0.48**	0.40	3.2E-03	1.1E-04
Average							2.2E-03	7.2E-05
Geometric Mean							1.0E-03	3.3E-05

Notes:

1. Estimated diameter of 10 percent passing (d_{10}) by extrapolating data on grainsize curve.
2. mm = millimeters; cm = centimeters; ft/s = feet/second.

ESU 2A Estimated K_{sat} ranged from about 2.3E-5 ft/s to 2.4E-4 ft/s, with geomean value of about 1.1E-4 ft/s.

ESU 2B Estimated K_{sat} ranged from about 1.3E-6 ft/s to 1.7E-4 ft/s, with geomean value of about 3.3E-5 ft/s.

Created with PTC Mathcad Express. See www.mathcad.com for more information.

Hydraulic conductivities for glacially-consolidated soils taken from USGS Open-File Report 00-228 *Geotechnical Properties for Landslide-Prone Seattle-Area Glacial Deposits* (2000)

Table 1. Dry (ρ_{dry}) and wet (ρ_{wet}) densities for the units shown in Figure 1.

Geologic Unit	ρ_{dry} kg/m^3	ρ_{wet} kg/m^3	Source	Reference
Recessional Outwash		2050	Laboratory	Robinson and others, 1983
		1600-1920	Not Specified	Galster and Laprade, 1991
Vashon Till	1920-2400	2160-2560	Laboratory	Olmstead, 1969
		2080-2400	Not Specified	Galster and Laprade, 1991
Esperance Sand (Advance Outwash)	1760	1920	Laboratory	Miller, 1989
		1920-2160	Not Specified	Galster and Laprade, 1991
Lawton Clay		1890	Laboratory	Robinson and others, 1983
		1600-1920	Not Specified	Galster and Laprade, 1991
Pre-Vashon		1910	Laboratory	Robinson and others, 1983
	1460	1920	Laboratory	Miller, 1989
		2080-2040	Not Specified	Galster and Laprade, 1991

Table 2. Hydraulic conductivities, k, for the units shown in Figure 1.

Geologic Unit	k m/day	Source	Reference
Recessional Outwash	$1x10^{-1}$- $1x10^{2}$	Not Specified	Laprade and Robinson, 1989
	$1x10^{-2}$- $1x10^{2}$	Not Specified	Galster and Laprade, 1991
	$1x10^{0}$-$1x10^{1}$	Field Tests	Morgan and Jones, 1995
	$1x10^{-2}$- $1x10^{2}$	Field Tests	Woodward and others, 1995
Vashon Till	$1x10^{-5}$- $1x10^{-2}$	Laboratory	Olmstead, 1969
	$1x10^{-5}$- $1x10^{-2}$	Not Specified	Laprade and Robinson, 1989
	$1x10^{-6}$- $1x10^{-1}$	Field Tests	Mills and Cordell, 1989
	$1x10^{-4}$- $1x10^{0}$	Not Specified	Galster and Laprade, 1991
	$1x10^{-5}$-$1x10^{1}$	Field Tests	Morgan and Jones, 1995
Esperance Sand (Advance Outwash)	$1x10^{-2}$- $1x10^{1}$	Not Specified	Mills and Cordell, 1989
	$1x10^{-1}$- $1x10^{2}$	Not Specified	Galster and Laprade, 1991
	$1x10^{0}$-$1x10^{1}$	Field Tests	Morgan and Jones, 1995
	$1x10^{-3}$-$1x10^{1}$	Field Tests	Woodward and others, 1995
Transitional silt-sands	$1x10^{-6}$-$1x10^{-1}$	Field Tests	Morgan and Jones, 1995
	$1x10^{-1}$-$1x10^{1}$	Field Tests	Woodward and others, 1995
Lawton Clay	$1x10^{-5}$- $1x10^{-3}$	Not Specified	Laprade and Robinson, 1989
	$1x10^{-4}$- $1x10^{-1}$	Not Specified	Galster and Laprade, 1991
Pre-Vashon	$1x10^{-5}$- $1x10^{-2}$	Not Specified	Laprade and Robinson, 1989
	$1x10^{-4}$- $1x10^{-1}$	Not Specified	Galster and Laprade, 1991

Appendix E.3 - Wall 05.85L-A Design Calculations

AASHTO Average Blowcount in Upper 100 feet

Soil Profile Type	v_s (fps)	N
S_A	>5000	N/A
S_B	2,500 to 5,000	
S_C	1,200 to 2,500	>50
S_D	600 to 1,200	15≤N≤50
S_E	<600	<15

Table 3.10.3.1-1—Site Class Definitions from AASHTO

Name	Nave	Soil Profile Type
W-217-20	97.0	C
H-1-85	28.4	D
H-2-85	24.1	D
H-3-85	24.3	D

Note:

Blowcount Percent (Energy is input BC/60). This spreadsheet approximates the layer thickness based on a function with depth, however, depending on the layering of the log, it may be necessary for the user to input their own layer thicknesses (i.e., clay layer extends at 7.5 ft and the blowcounts need to be weighted to reflect that thickness).

Spreadsheet based on Section 3.10.3.1 of American Association of State Highway and Transportation Officials (AASHTO).

AASHTO Average Blowcount in Upper 100 feet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	W-217-20								H-1-85							
2	Depth	Field Blowcount	Energy Corrected Blowcount, N_i	Layer thickness d_i (feet)	Sum(d_i)	d_i/N_i	Sum(d_i/N_i)	N_{ave}	Depth	Field Blowcount	Energy Corrected Blowcount, N_i	Layer thickness di (feet)	Sum(di)	di/Ni	Sum(di/Ni)	Nave
3	2.5	93	100	3.75	100	0.04	1.0309	97.0	1	4	4	2	100	0.50	3.5	28.4
4	5	63	92	2.5		0.03			3	8	8	2		0.25		
5	7.5	111	100	2.5		0.03			5	3	3	2.25		0.75		
6	10	100	100	3.75		0.04			7.5	4	4	2.5		0.63		
7	15	100	100	5		0.05	Driving Energy	88%	10	10	10	2.5		0.25	Driving Energy	60%
8	20	300	100	5		0.05			12.5	9	9	2.5		0.28		
9	25	51	75	5		0.07			15	138	100	2.5		0.03		
10	30	82	100	5		0.05			17.5	297	100	2.5		0.03		
11	35	55	81	5		0.06			20	400	100	3.75		0.04		
12	40	100	100	5		0.05			25	300	100	77.5		0.78		
13	45	110	100	5		0.05								End of Data		
14	50	300	100	5		0.05								End of Data		
15	55	120	100	5		0.05								End of Data		
16	60	120	100	42.5		0.43								End of Data		
17						End of Data								End of Data		
18						End of Data								End of Data		
19						End of Data								End of Data		
20						End of Data								End of Data		
21						End of Data								End of Data		
22						End of Data								End of Data		
23						End of Data								End of Data		
24						End of Data								End of Data		
25						End of Data								End of Data		
26						End of Data								End of Data		
27						End of Data								End of Data		
28						End of Data								End of Data		

AASHTO Average Blowcount in Upper 100 feet

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF
1	H-2-85								H-3-85							
2	**Depth**	**Field Blowcount**	**Energy Corrected Blowcount, N_i**	**Layer thickness di (feet)**	**Sum(di)**	**di/Ni**	**Sum(di/Ni)**	**Nave**	**Depth**	**Field Blowcount**	**Energy Corrected Blowcount, N_i**	**Layer thickness di (feet)**	**Sum(di)**	**di/Ni**	**Sum(di/Ni)**	**Nave**
3	1		7	2	100	0.29	4.1468	**24.1**	1	5	5	2	100	0.40	4.1	**24.3**
4	3		17	2		0.12			3	3	3	2		0.67		
5	5		13	2.25		0.17			5	5	5	2.25		0.45		
6	7.5		20	2.5		0.13			7.5	11	11	2.5		0.23		
7	10		8	2.5		0.31	Driving Energy	60%	10	5	5	2.5		0.50	Driving Energy	60%
8	12.5		7	2.5		0.36			12.5	8	8	2.5		0.31		
9	15		7	2.5		0.36			15	6	6	2.5		0.42		
10	17.5		20	2.5		0.13			17.5	11	11	2.5		0.23		
11	20		10	2.5		0.25			20	19	19	2.5		0.13		
12	22.5		7	2.5		0.36			22.5	118	100	2.5		0.03		
13	25		18	2.5		0.14			25	153	100	76.25		0.76		
14	27.5		17	2.5		0.15								End of Data		
15	30		11	2.5		0.23								End of Data		
16	32.5		21	2.5		0.12								End of Data		
17	35		16	2.5		0.16								End of Data		
18	37.5		71	63.75		0.90								End of Data		
19						End of Data								End of Data		
20						End of Data								End of Data		
21						End of Data								End of Data		
22						End of Data								End of Data		
23						End of Data								End of Data		
24						End of Data								End of Data		
25						End of Data								End of Data		
26						End of Data								End of Data		
27						End of Data								End of Data		
28						End of Data								End of Data		
29																

05.85L-A

BEToolbox™

Spectra

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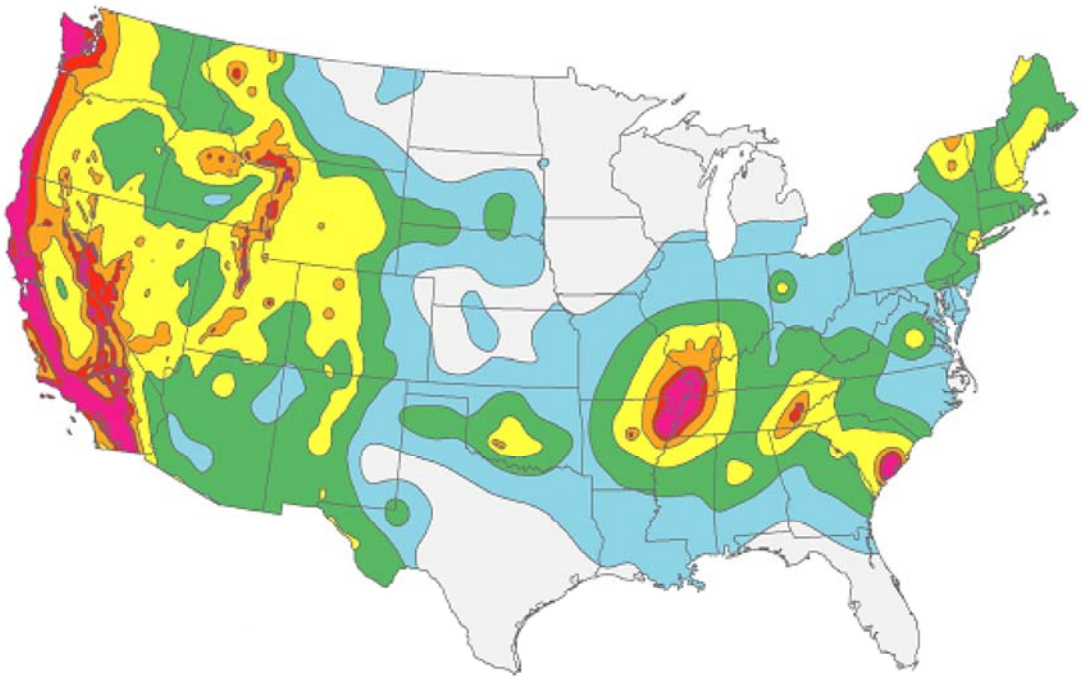
Version 6.0.0.6 BETA - Built on Jan 7 2021



05.85L-A

WSDOT Bridge Design Manual
2014 Seismic Hazard Map, 7% probability of exceedance in 75 years

Site Coordinates (Latitude,Longitude): 47.5097° N, 122.198° W
Site Soil Classification: Site Class D - Stiff Soil

Seismic hazard maps are for sites at the boundary of Site Classes B and C, which is $\bar{v}_s$ = 2500 ft/s (760 m/s). Adjustments for other Site Classes are made as needed.

Period (sec)	Sa (g)	
0.0	0.433	PGA - Site Class B/C Boundary
0.2	0.987	S_s - Site Class B/C Boundary
1.0	0.283	S_1 - Site Class B/C Boundary

Values of Site Coefficient, F_{pga}, for Peak Ground Acceleration

Site Class	Mapped Peak Ground Acceleration Coefficient (PGA)					
	PGA≤ 0.10	PGA= 0.20	PGA= 0.30	PGA= 0.40	PGA= 0.50	PGA≥ 0.60
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.2	1.2	1.2	1.2	1.2
D	1.6	1.4	1.3	1.2	1.1	1.1
E	2.4	1.9	1.6	1.4	1.2	1.1

For Site Class D, F_{pga} = 1.167

Values for Site Coefficient, F_a, for 0.2 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 0.2 sec (S_s)					
	S_s≤ 0.25	S_s= 0.50	S_s= 0.75	S_s= 1.00	S_s= 1.25	S_s≥ 1.50
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	1.0	0.9	0.9

For Site Class D, F_a = 1.105

Values of Site Coefficient, F_v, for 1.0 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 1.0 sec (S_1)					
	S_1≤ 0.1	S_1= 0.2	S_1= 0.3	S_1= 0.4	S_1= 0.5	S_1≥ 0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2	2.0	1.9	1.8	1.7
E	4.2	3.3	2.8	2.4	2.2	2.0

For Site Class D, F_v = 2.034

$A_s = F_{pga}$ PGA = (1.167)(0.433g) = 0.505g
$S_{DS} = F_a S_s$ = (1.105)(0.987g) = 1.090g
$S_{D1} = F_v S_1$ = (2.034)(0.283g) = 0.576g
$T_o = 0.2T_s$ = (0.2)(0.528) = 0.106 sec
$T_s = S_{D1}/S_{DS}$ = (0.576)/(1.090) = 0.528 sec

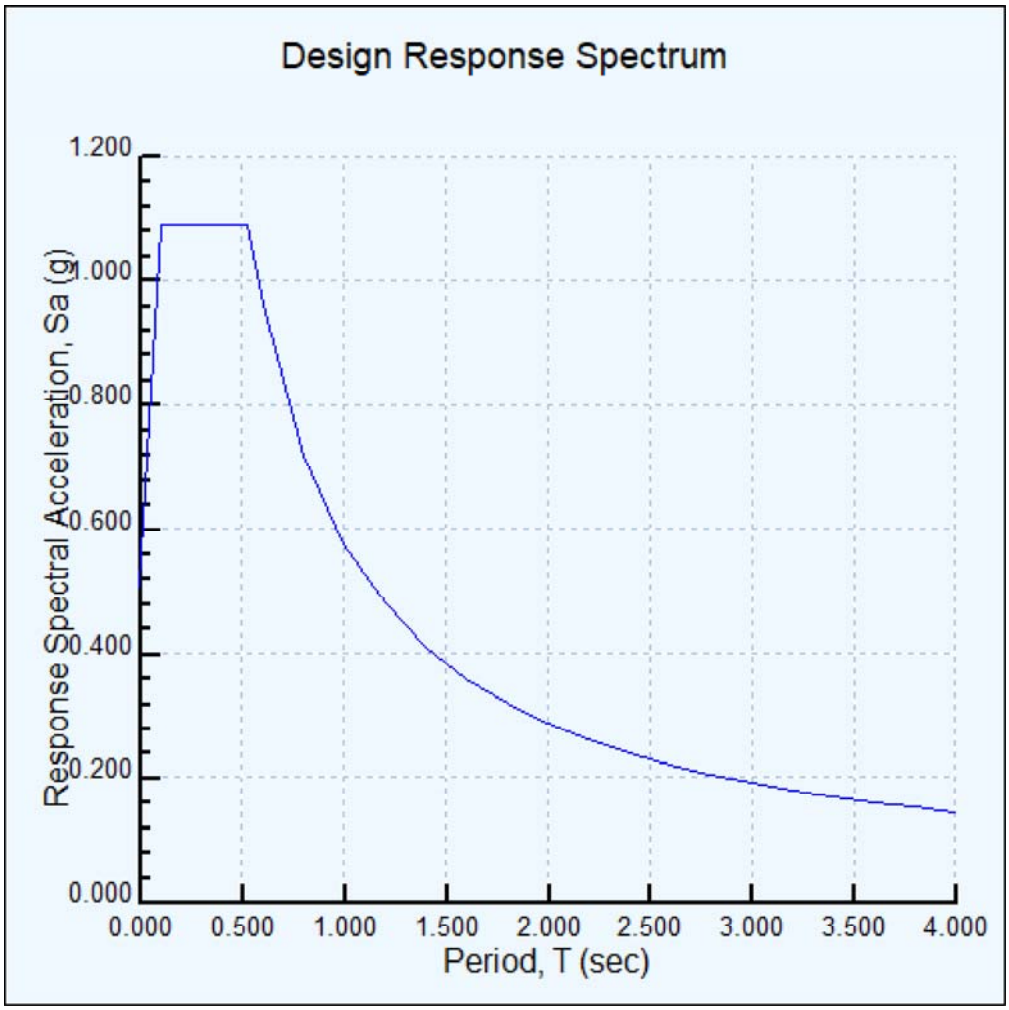
05.85L-A

Partitions for Seismic Design Categories A, B, C, and D

S_{D1}	SDC
$S_{D1} < 0.15$	A
$0.15 \le S_{D1} < 0.30$	B
$0.30 \le S_{D1} < 0.50$	C
$0.50 \le S_{D1}$	D

Seismic Design Category (SDC) = D

Period, T (sec)	Sa (g)	
0.000	0.505	
0.106	1.090	T_o
0.200	1.090	
0.400	1.090	
0.528	1.090	T_s
0.600	0.959	
0.800	0.720	
1.000	0.576	
1.200	0.480	
1.400	0.411	
1.600	0.360	
1.800	0.320	
2.000	0.288	
2.200	0.262	
2.400	0.240	
2.600	0.221	
2.800	0.206	
3.000	0.192	
3.200	0.180	
3.400	0.169	
3.600	0.160	
3.800	0.151	
4.000	0.144	



Calculating Wall Seismic Acceleration Considering Wave Scattering
Wall 05.85L-A

Per National Cooperative Highway Research Program (NCHRP) Report 611 the site class adjusted peak ground acceleration (PGA), As, can be corrected to account for vertical variations in the average ground acceleration observed behind tall retaining walls and/ or slopes greater than 20-feet in height by applying a wall height acceleration reduction factor (or α coefficient) to the As.

Site Class D

$M := 7.0$ Mean earthquake magnitude at the PGA period based on the Hart Crowser seismic design report "I-405 R2B Segment 1a Site-Specific Hazard Analysis RFU," dated March 25, 2021.

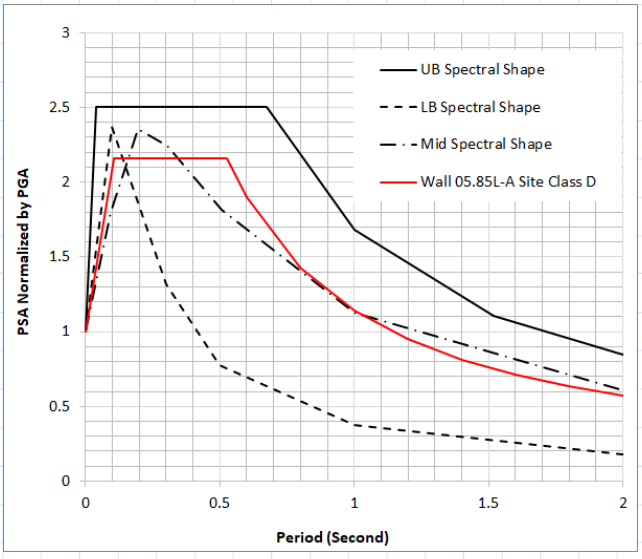
Determine response spectrum using WSDOT Bridge Engineering Software BEToolbox/ BridgeLink Version 6.0.0.6 BETA in accordance with the WSDOT BDM based on the projected ground motion at the project site that has a 7 percent (SEE) probability of exceedance in a 75-year period (approximate 1,000-year return period).

$A_s := 0.505$ (g) Site Class Adjusted PGA

$S_{D1} := 0.576$

Determine the most appropriate spectral curve shape based on NCHRP Report 611 Figure 5-4.

1. Normalize response spectrum by the peak ground acceleration (PGA).
2. The peak spectral acceleration (PSA) normalized by PGA is then overlaid on the spectral shapes shown on Figure 5-4 to determine the most appropriate spectral curve shape for the design condition. Three spectral shapes shown on Figure 5-4 include an upper bound (UB), lower bound (LB), and intermediate (Mid) spectral shape.



The Mid spectral shape was selected.

Determine wall height acceleration reduction factor (or α coefficient) using wall height and the spectral shapes based on NCHRP Report 611 Figure 6-13.

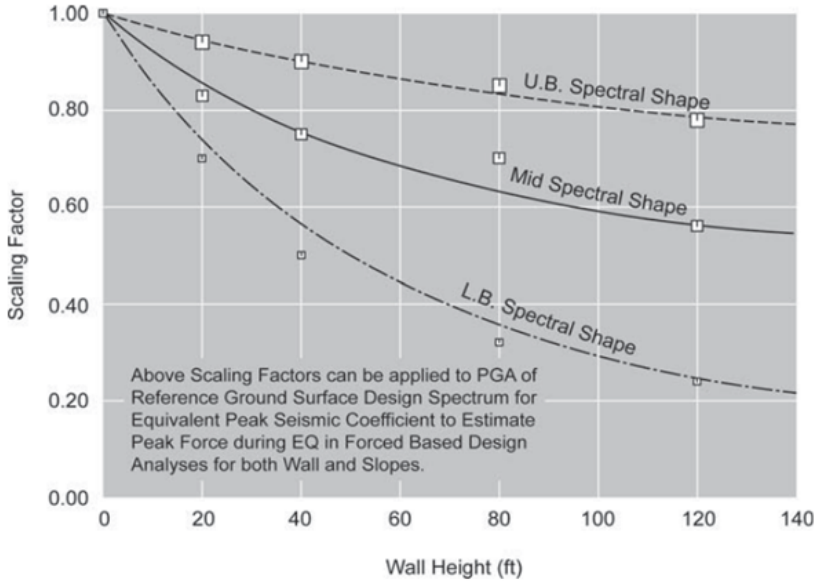


Figure 6-13. Resultant wave scattering α coefficients for retaining wall design.

Station 1+90 (Current design)

For Lateral Earth Pressure calculations, slope height is taken as 28.5 ft. (vertical distance between proposed ground surface prior to Forward Compatible Wall construction and SEW wall base at the back of wall heel) The wall height acceleration reduction factor selected from Figure 6-13 is:

$$\alpha := 0.815$$

Wall seismic acceleration considering wave scattering

$$PGA_a := A_s \cdot \alpha = 0.412$$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$$k_h := \frac{PGA_a}{2} = 0.206$$

For Compound Stability calculations, the slope height is taken as 40.5 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$\alpha := 0.765$

Wall seismic acceleration considering wave scattering

$PGA_a := A_s \cdot \alpha = 0.386$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$k_h := \frac{PGA_a}{2} = 0.193$

For Global Stability calculations, the slope height is taken as 44 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$\alpha := 0.753$

Wall seismic acceleration considering wave scattering

$PGA_a := A_s \cdot \alpha = 0.38$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$k_h := \frac{PGA_a}{2} = 0.190$

Station 1+90 (with Forward Compatible Wall)

For Compound Stability calculations, the slope height is taken as 40.5 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$\alpha := 0.765$

Wall seismic acceleration considering wave scattering

$PGA_a := A_s \cdot \alpha = 0.386$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$k_h := \frac{PGA_a}{2} = 0.193$

For Global Stability calculations, the slope height is taken as 43 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$$\alpha := 0.756$$

Wall seismic acceleration considering wave scattering

$$PGA_a := A_s \cdot \alpha = 0.382$$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$$k_h := \frac{PGA_a}{2} = 0.191$$

General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	W-217-20
Analysis by:	BZ
Date Analyzed:	4/12/2021
Checked by:	TB
Date Checked:	4/12/2021

Sampling Information	
Depth to Groundwater (ft):	10.6
SPT Liner (Yes/No):	No
Hammer Energy, %:	88
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	4

Earthquake Information	
Max Acceleration (As) (g) :	0.505
Earthquake Magnitude:	7.00

GW based on SEEP/W analysis

Site Class D SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

Collect Data From gINT

Automate %F from USCS

Auto %F from WSDOT GDM

COMPUTE

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	2.5	93	SM	45	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	5.0	63	SM	30	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	7.5	111	SM	37	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	10.0	100	SM	40	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	15.0	100	SM	40	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	20.0	300	SM	40	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	25.0	51	ML	90	ESU 5B	130	18.0	Non-Liquefiable	Non-Liquefiable
	30.0	82	ML	90	ESU 5B	130		Non-Liquefiable	Non-Liquefiable
	35.0	55	CL	92	ESU 5B	130	16.0	Non-Liquefiable	Non-Liquefiable
	40.0	100	CH	73	ESU 5B	125	28.0	Non-Liquefiable	Non-Liquefiable
	45.0	110	CL	70	ESU 5B	130		Non-Liquefiable	Non-Liquefiable
	50.0	300	SW	11	ESU 4B	140		Non-Liquefiable	Non-Liquefiable
	55.0	120	SM	30	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	60.0	120	GM	30	ESU 4B	130		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	2.5	93	SM	45	166	167	2.00	2.00	0.0	0.0	0.0	0.0	167.5	173.9	164.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	5.0	63	SM	30	108	101	2.00	2.00	0.0	0.0	0.0	0.0	100.8	125.7	101.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.5	111	SM	37	155	144	2.00	2.00	0.0	0.0	0.0	0.0	159.7	191.9	161.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	10.0	100	SM	40	151	142	2.00	2.00	0.0	0.0	0.0	0.0	141.7	159.1	142.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	15.0	100	SM	40	154	148	2.00	2.00	0.0	0.0	0.0	0.0	148.2	156.6	147.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	20.0	300	SM	40	142	141	2.00	2.00	0.0	0.0	0.0	0.0	423.5	428.5	417.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	25.0	51	ML	90	68	69	2.00	2.00	0.0	0.0	0.0	0.0	69.1	67.4	67.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	30.0	82	ML	90	107	113	2.00	2.00	0.0	0.0	0.0	0.0	112.9	106.7	108.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	35.0	55	CL	92	67	73	2.00	2.00	0.0	0.0	0.0	0.0	73.4	67.4	69.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	40.0	100	CH	73	116	130	2.00	2.00	0.0	0.0	0.0	0.0	130.1	116.7	121.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	45.0	110	CL	70	110	127	2.00	2.00	0.0	0.0	0.0	0.0	139.5	122.4	128.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	50.0	300	SW	11	103	124	2.00	2.00	0.0	0.0	0.0	0.0	370.5	317.4	336.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	55.0	120	SM	30	98	121	2.00	2.00	0.0	0.0	0.0	0.0	145.1	122.0	129.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	60.0	120	GM	30	94	119	2.00	2.00	0.0	0.0	0.0	0.0	142.3	117.6	125.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

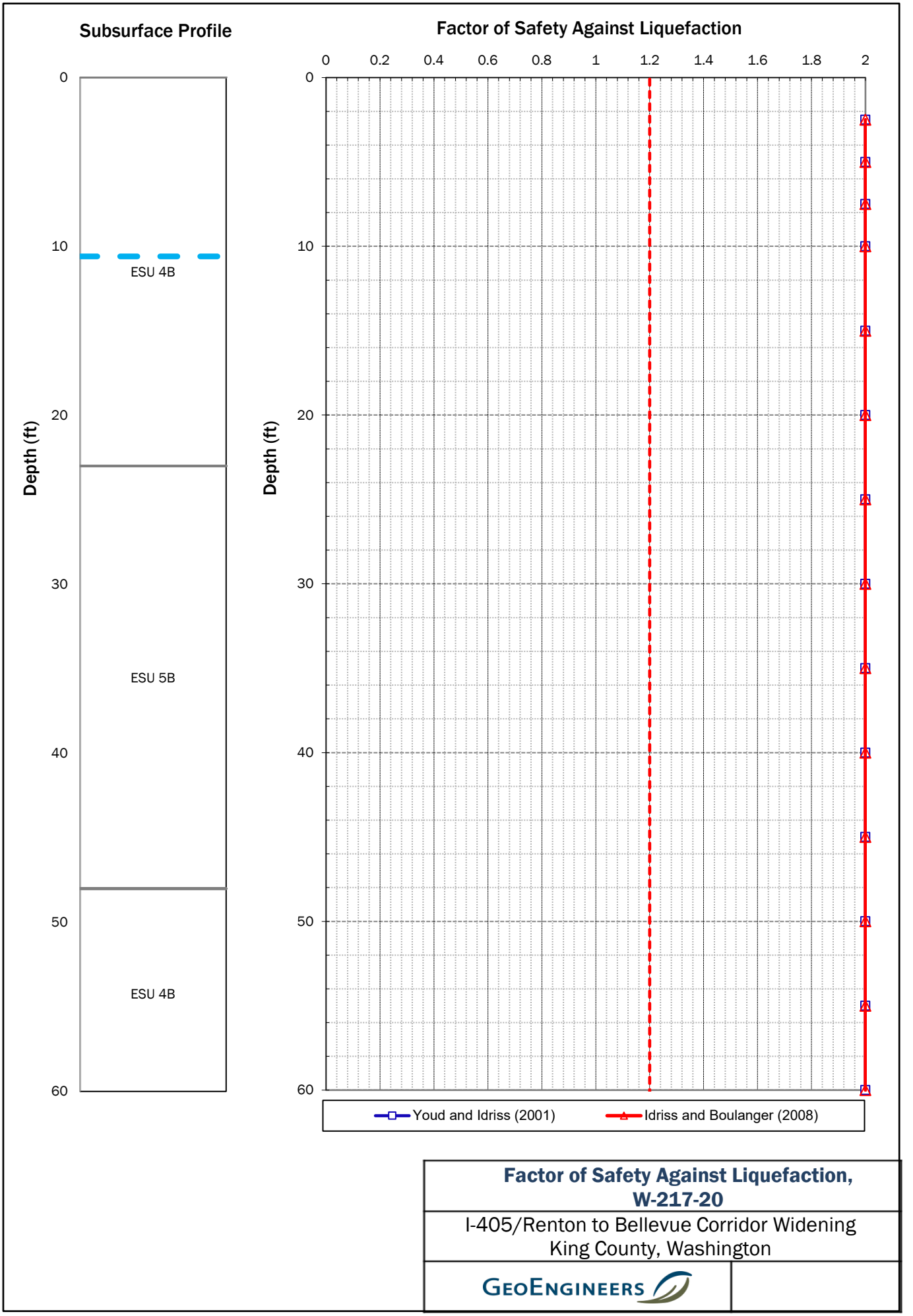
Seismic Parameters	
Max Acceleration (As) (g) :	0.505
Earthquake Magnitude:	7.00

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, W-217-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

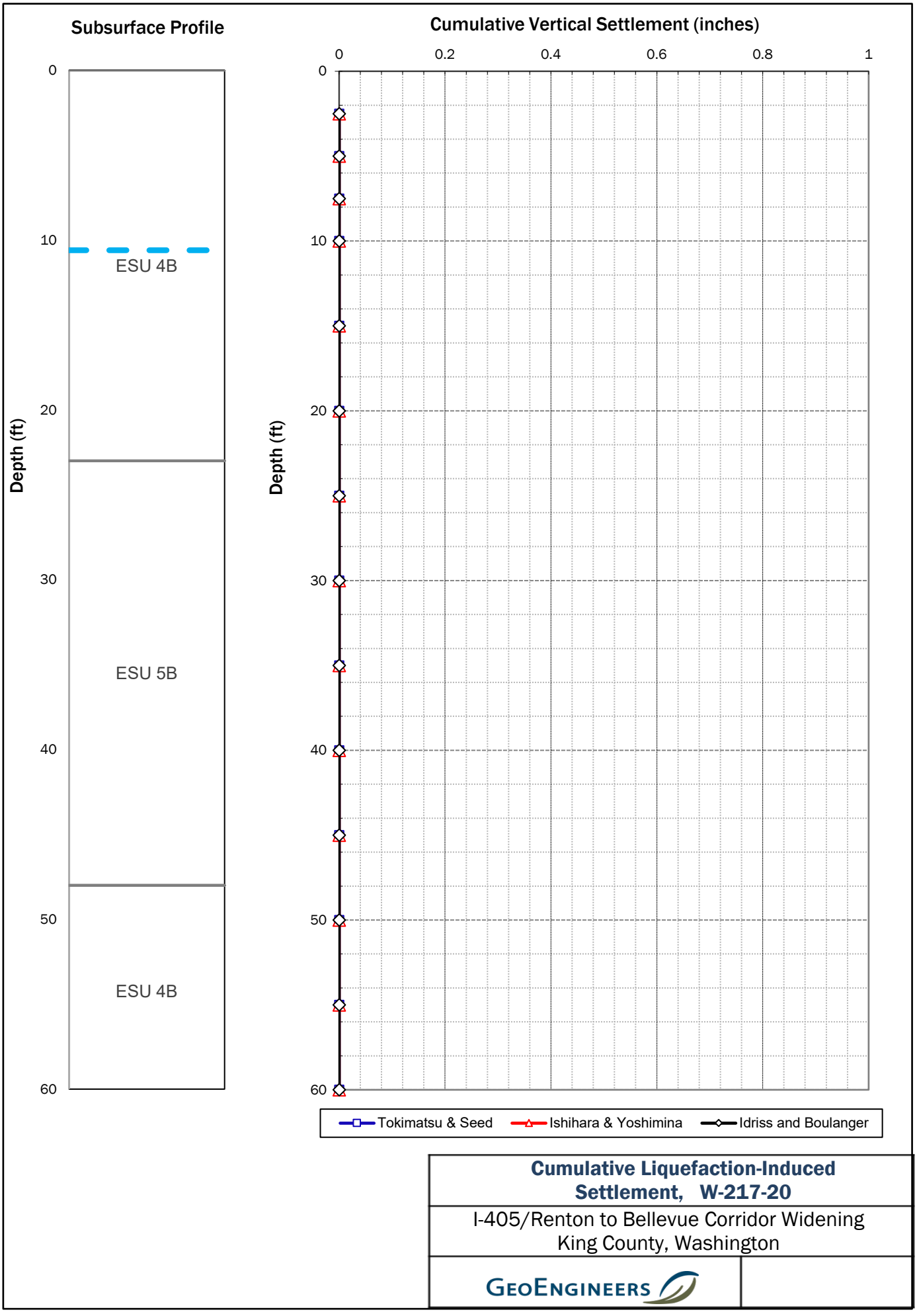


Factor of Safety Against Liquefaction, W-217-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021



Cumulative Liquefaction-Induced Settlement, W-217-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021

General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	H-1-85
Analysis by:	BZ
Date Analyzed:	4/12/2021
Checked by:	TB
Date Checked:	4/12/2021

Sampling Information	
Depth to Groundwater (ft):	19.6
SPT Liner (Yes/No):	No
Hammer Energy, %:	60
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	3

Earthquake Information	
Max Acceleration (g) :	0.505
Earthquake Magnitude:	7.00

GW based on SEEP/W analysis

Site Class D SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Collect Data From gINT

Automate %F from USCS

Auto %F from WSDOT GDM

COMPUTE

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unsaturated", "cohesive",etc)	User Override*
	1.0	4	SM	18	ESU 1A	90		Unsaturated	
	3.0	8	SM	18	ESU 1A	110		Unsaturated	
	5.0	3	SM	22	ESU 2A	90		Unsaturated	
	7.5	4	SM	28	ESU 2A	90		Unsaturated	
	10.0	10	SM	18	ESU 2A	110		Unsaturated	
	12.5	9	SM	31	ESU 2A	110		Unsaturated	
	15.0	138	SP-SM	8	ESU 4B	135		Non-Liquefiable	Non-Liquefiable
	17.5	297	SP-SM	9	ESU 4B	135		Non-Liquefiable	Non-Liquefiable
	20.0	400	SP-SM	7	ESU 4B	135		Non-Liquefiable	Non-Liquefiable
	25.0	300	SP-SM	6	ESU 4B	135		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	1.0	4	SM	18	5	5	2.00	2.00	0.0	0.0	0.0	0.0	5.1	5.1	6.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	3.0	8	SM	18	10	10	2.00	2.00	0.0	0.0	0.0	0.0	10.2	10.2	9.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	5.0	3	SM	22	4	4	2.00	2.00	0.0	0.0	0.0	0.0	4.1	4.1	3.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.5	4	SM	28	5	5	2.00	2.00	0.0	0.0	0.0	0.0	5.4	5.4	4.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	10.0	10	SM	18	11	12	2.00	2.00	0.0	0.0	0.0	0.0	12.2	12.4	10.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	12.5	9	SM	31	9	10	2.00	2.00	0.0	0.0	0.0	0.0	9.8	9.9	8.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	15.0	138	SP-SM	8	107	102	2.00	2.00	0.0	0.0	0.0	0.0	141.0	150.7	141.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	17.5	297	SP-SM	9	99	97	2.00	2.00	0.0	0.0	0.0	0.0	288.7	294.7	285.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	20.0	400	SP-SM	7	92	93	2.00	2.00	0.0	0.0	0.0	0.0	373.8	368.3	365.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	25.0	300	SP-SM	6	86	90	2.00	2.00	0.0	0.0	0.0	0.0	269.5	256.4	259.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

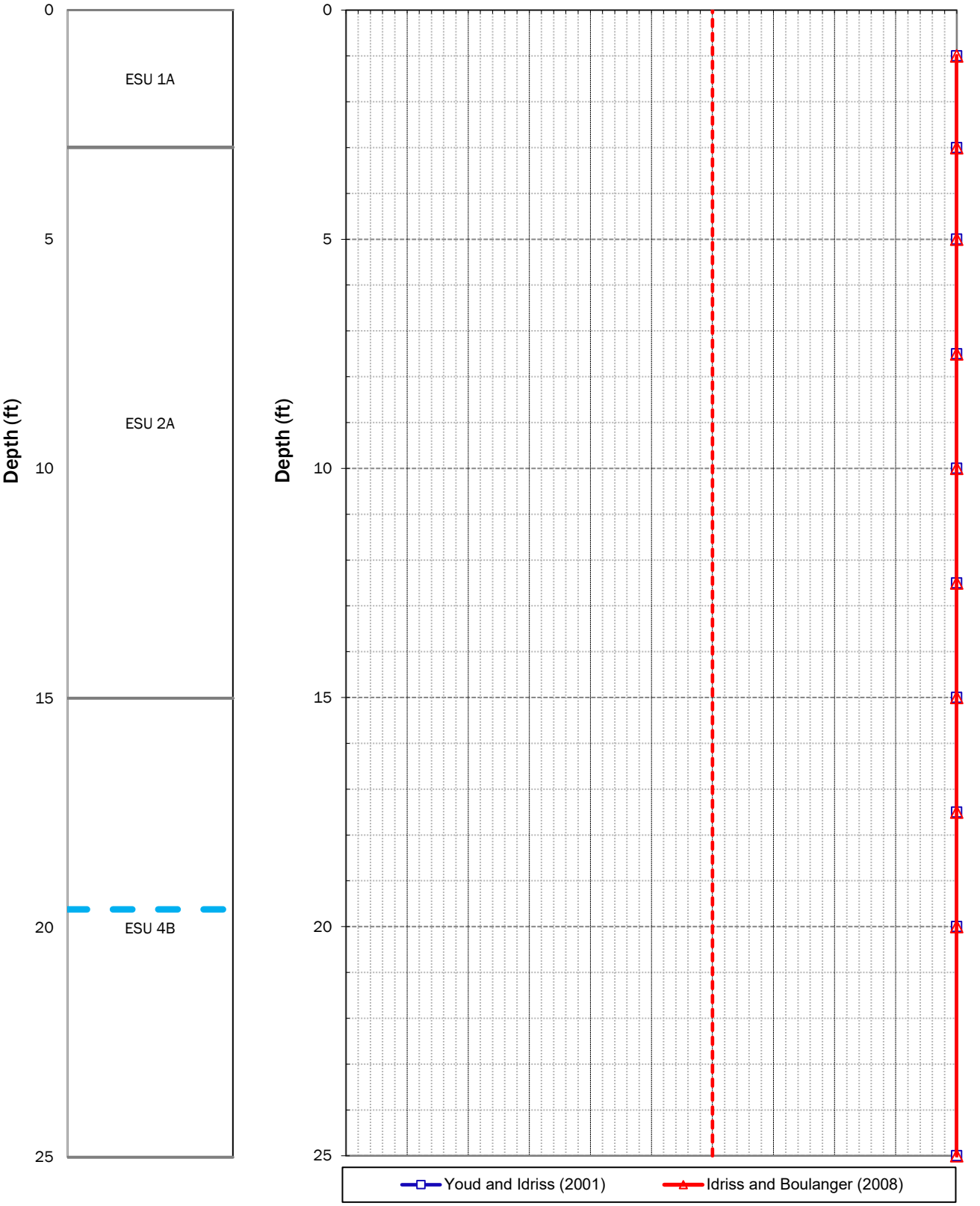
Seismic Parameters	
Max Acceleration (g) :	0.505
Earthquake Magnitude:	7.00

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, H-1-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

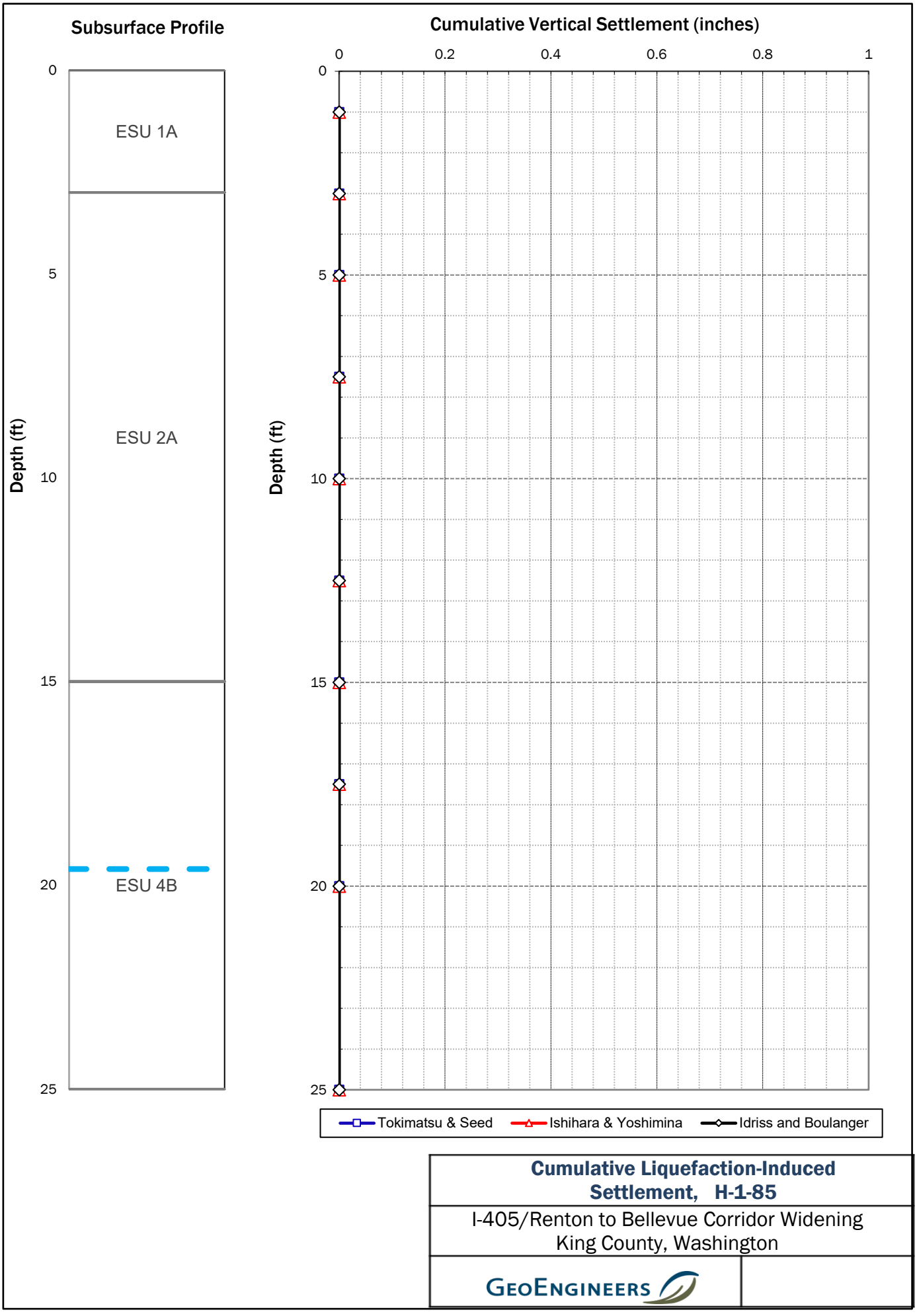


Factor of Safety Against Liquefaction, H-1-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021



Cumulative Liquefaction-Induced Settlement, H-1-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021

General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	H-2-85
Analysis by:	BZ
Date Analyzed:	4/12/2021
Checked by:	TB
Date Checked:	4/12/2021

Sampling Information	
Depth to Groundwater (ft):	24.1
SPT Liner (Yes/No):	No
Hammer Energy, %:	60
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	3

Earthquake Information	
Max Acceleration (As) (g) :	0.505
Earthquake Magnitude:	7.00

GW based on SEEP/W analysis

Site Class D SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Collect Data From gINT

Automate %F from USCS

Auto %F from WSDOT GDM

COMPUTE

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	1.0	7	SM	15	ESU 1A	110		Unsaturated	
	3.0	17	SM	24	ESU 2A	115		Unsaturated	
	5.0	13	SM	15	ESU 2A	110		Unsaturated	
	7.5	20	SM	18	ESU 2A	115		Unsaturated	
	10.0	8	SM	16	ESU 2A	110		Unsaturated	
	12.5	7	SM	30	ESU 2A	110		Unsaturated	
	15.0	7	SM	22	ESU 2A	110		Unsaturated	
	17.5	20	SM	25	ESU 2A	115		Unsaturated	
	20.0	10	SM	27	ESU 2A	110		Unsaturated	
	22.5	7	SM	24	ESU 2A	110		Unsaturated	
	25.0	18	SM	26	ESU 2B	115			
	27.5	17	ML	60	ESU 2B	115			
	30.0	11	ML	51	ESU 2B	110			
	32.5	21	SM	33	ESU 2B	115			
	35.0	16	SM	22	ESU 2B	110			
	37.5	71	SP-SM	7	ESU 4B	135		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	1.0	7	SM	15	9	9	2.00	2.00	2.1	4.3	3.3	1.9	8.9	8.9	10.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	3.0	17	SM	24	21	22	2.00	2.00	2.1	4.3	3.3	1.9	21.7	21.7	20.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	5.0	13	SM	15	16	18	2.00	2.00	2.1	4.3	3.3	1.9	17.7	17.7	14.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.5	20	SM	18	22	23	2.00	2.00	2.1	4.3	3.3	1.9	22.8	25.3	20.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	10.0	8	SM	16	9	9	2.00	2.00	2.1	4.3	3.3	1.9	9.4	9.3	8.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	12.5	7	SM	30	7	7	2.00	2.00	2.1	4.3	3.3	1.9	7.4	7.3	6.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	15.0	7	SM	22	7	8	2.00	2.00	2.1	4.3	3.3	1.9	7.5	7.5	7.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	17.5	20	SM	25	20	20	2.00	2.00	2.1	4.3	3.3	1.9	19.6	19.7	19.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	20.0	10	SM	27	9	9	2.00	2.00	2.1	4.3	3.3	1.9	9.2	9.2	9.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	22.5	7	SM	24	6	6	2.00	2.00	2.1	4.3	3.3	1.9	6.1	6.1	6.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	25.0	18	SM	26	15	15	0.82	0.73	2.1	4.3	3.3	1.9	15.3	15.0	15.3	526	391	402	1131	519	802
	27.5	17	ML	60	14	14	0.80	0.67	1.7	3.6	2.8	1.7	14.1	13.9	14.2	537	385	444	1584	471	916
	30.0	11	ML	51	9	9	0.56	0.49	1.3	2.7	2.1	1.3	9.3	9.3	9.5	331	297	341	459	296	424
	32.5	21	SM	33	17	18	0.91	0.81	0.8	1.5	1.2	0.6	17.9	17.3	17.9	734	499	542	2145	707	1217
	35.0	16	SM	22	13	13	0.59	0.55	0.5	1.0	0.8	0.5	13.2	12.9	13.4	441	412	391	585	457	487
	37.5	71	SP-SM	7	55	63	2.00	2.00	0.0	0.0	0.0	0.0	62.6	55.8	58.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

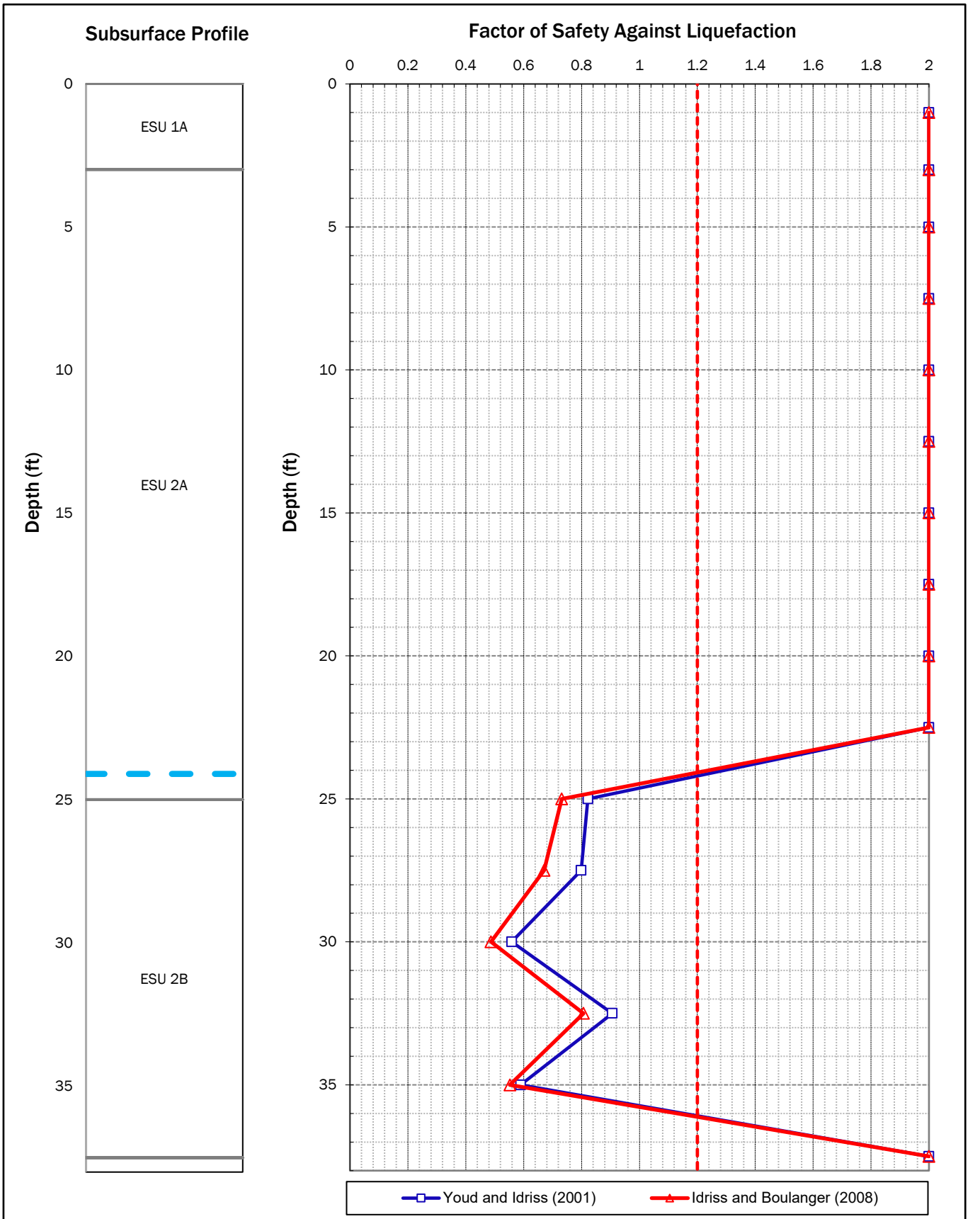
Seismic Parameters	
Max Acceleration (As) (g) :	0.505
Earthquake Magnitude:	7.00

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, H-2-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

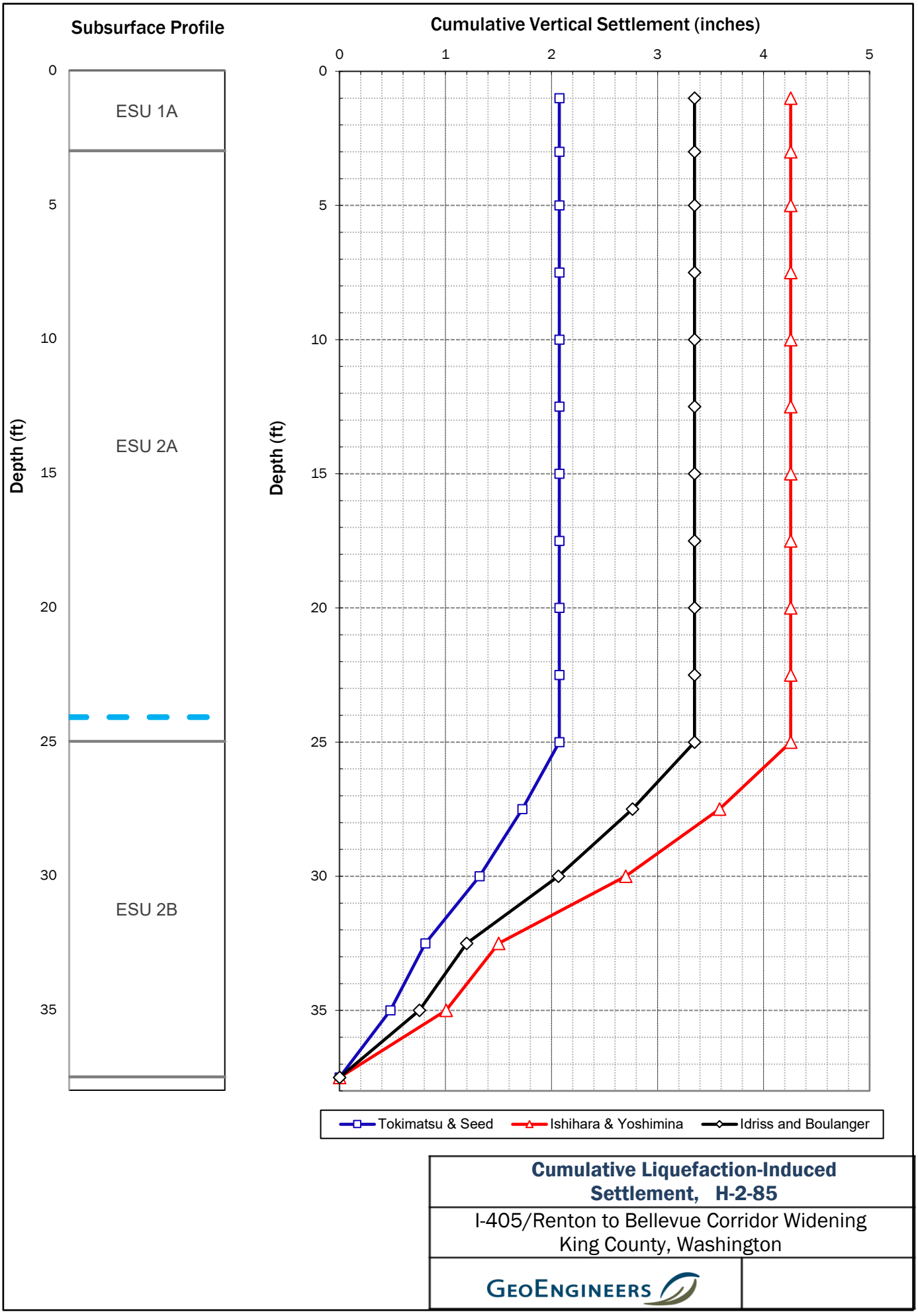


Factor of Safety Against Liquefaction, H-2-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021



Cumulative Liquefaction-Induced Settlement, H-2-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021

General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	H-3-85
Analysis by:	BZ
Date Analyzed:	4/12/2021
Checked by:	TB
Date Checked:	4/12/2021

Sampling Information	
Depth to Groundwater (ft):	30.0
SPT Liner (Yes/No):	No
Hammer Energy, %:	60
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	3

Earthquake Information	
Max Acceleration (g) :	0.505
Earthquake Magnitude:	7.00

GW based on SEEP/W analysis

Site Class D SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Collect Data From gINT

Automate %F from USCS

Auto %F from WSDOT GDM

COMPUTE

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	1.0	5	SP	4	ESU 1A	105		Unsaturated	
	3.0	3	SP	4	ESU 1A	105		Unsaturated	
	5.0	5	SP	4	ESU 1A	105		Unsaturated	
	7.5	11	SP-SM	5	ESU 1A	115		Unsaturated	
	10.0	5	SP-SM	10	ESU 2A	100		Unsaturated	
	12.5	8	SP-SM	12	ESU 2A	115		Unsaturated	
	15.0	6	SM	12	ESU 2A	100		Unsaturated	
	17.5	11	SM	19	ESU 2A	110		Unsaturated	
	20.0	19	ML	70	ESU 2B	115		Unsaturated	
	22.5	118	SP-SM	11	ESU 4B	135		Non-Liquefiable	Non-Liquefiable
	25.0	153	SM	11	ESU 4B	130		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	1.0	5	SP	4	6	6	2.00	2.00	0.0	0.0	0.0	0.0	6.4	6.4	7.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	3.0	3	SP	4	4	4	2.00	2.00	0.0	0.0	0.0	0.0	3.8	3.8	3.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	5.0	5	SP	4	6	7	2.00	2.00	0.0	0.0	0.0	0.0	6.8	6.8	5.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.5	11	SP-SM	5	12	14	2.00	2.00	0.0	0.0	0.0	0.0	14.1	14.2	11.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	10.0	5	SP-SM	10	5	6	2.00	2.00	0.0	0.0	0.0	0.0	6.3	6.0	5.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	12.5	8	SP-SM	12	8	9	2.00	2.00	0.0	0.0	0.0	0.0	8.6	8.5	7.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	15.0	6	SM	12	6	7	2.00	2.00	0.0	0.0	0.0	0.0	6.7	6.6	6.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	17.5	11	SM	19	11	11	2.00	2.00	0.0	0.0	0.0	0.0	11.1	11.1	10.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	20.0	19	ML	70	18	18	2.00	2.00	0.0	0.0	0.0	0.0	20.0	20.0	20.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	22.5	118	SP-SM	11	88	91	2.00	2.00	0.0	0.0	0.0	0.0	107.3	103.1	103.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	25.0	153	SM	11	82	88	2.00	2.00	0.0	0.0	0.0	0.0	134.7	125.8	128.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

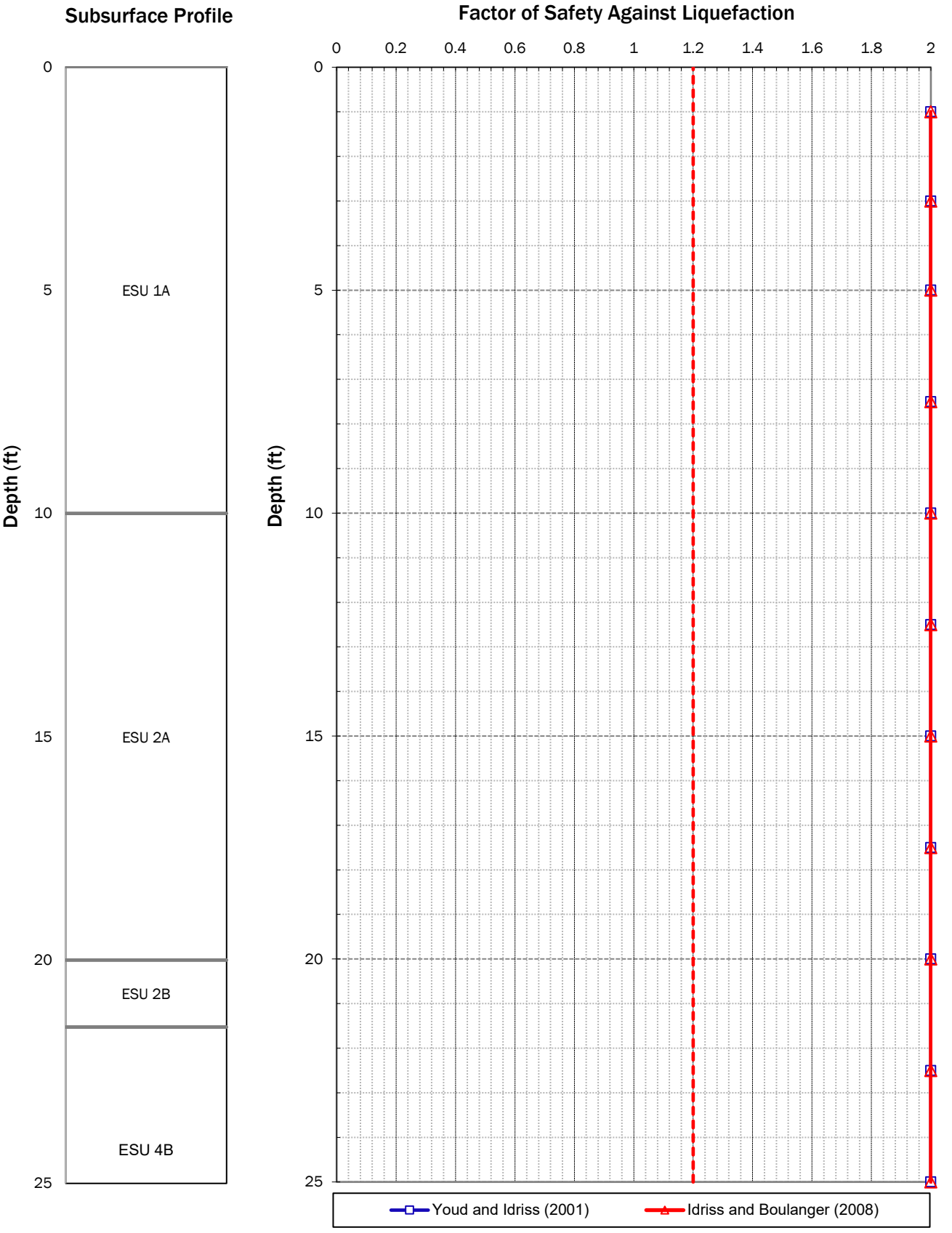
Seismic Parameters	
Max Acceleration (g) :	0.505
Earthquake Magnitude:	7.00

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, H-3-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

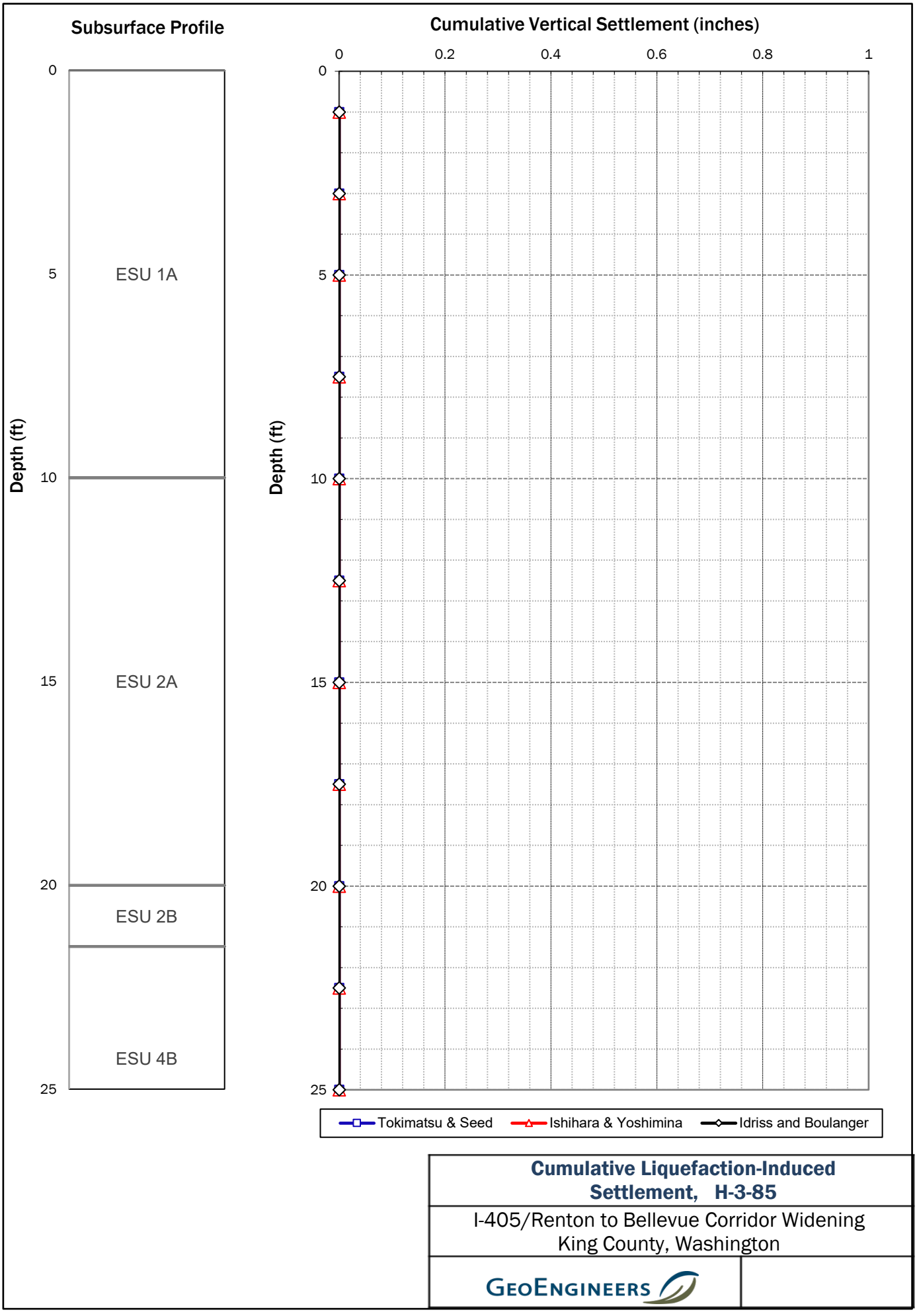


Factor of Safety Against Liquefaction, H-3-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021



Cumulative Liquefaction-Induced Settlement, H-3-85

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/12/2021

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	I-405/Renton to Bellevue Corridor Widening
Owner:	WSDOT
Job Number:	00180-366-01
Analysis by:	YTT
Date/Time:	1/11/2022 3:32 PM
Checked by:	TB

Input Parameters

Material	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
ESU 2A	32	-27	27	21	0	0	110	47.6	1	0	0

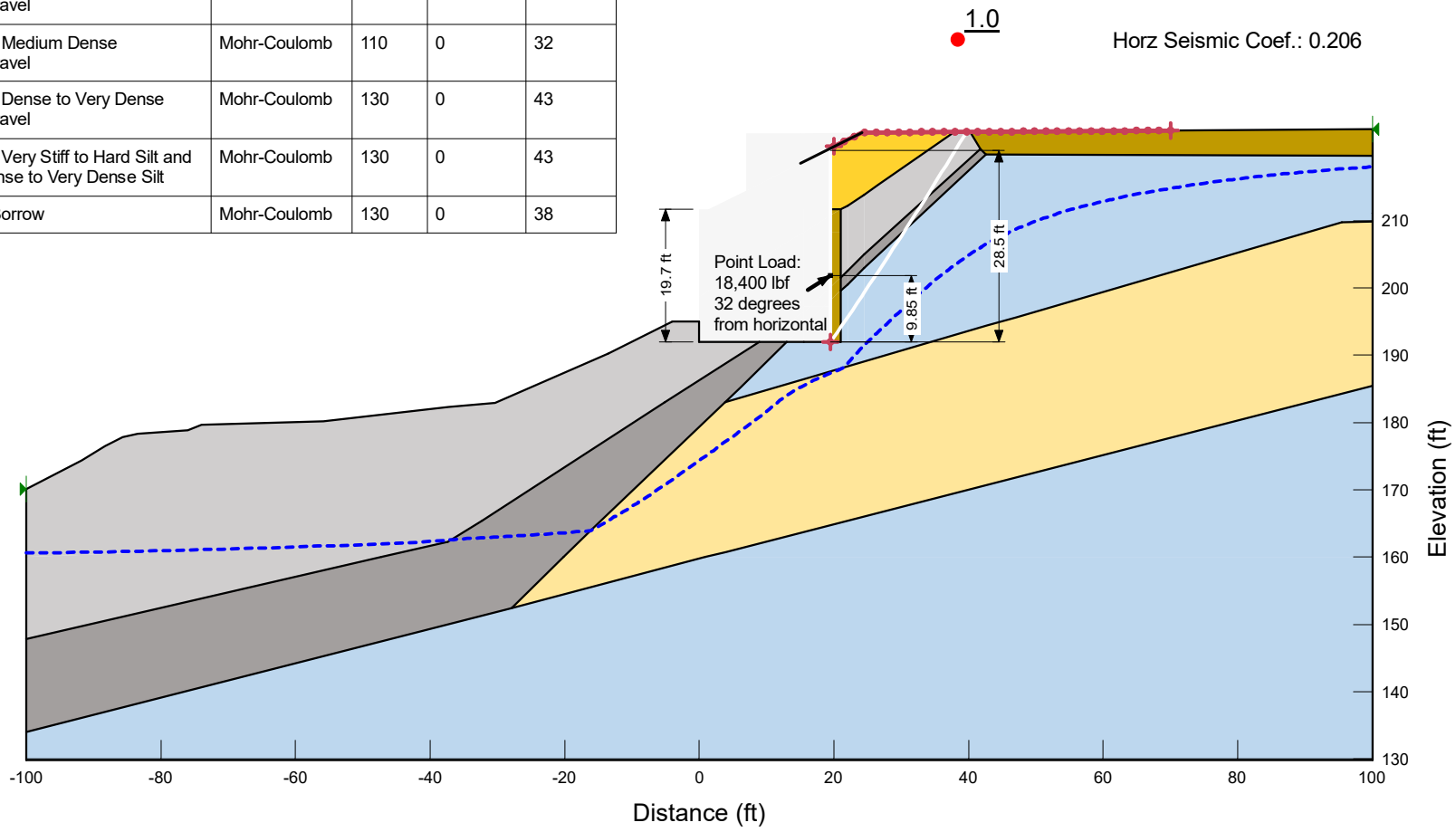
Lateral Earth Pressures

Output

Material	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic				Seismic Pressure - Rectangular
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], X	K_{ae}	γ_{ae} (pcf)	γ'_{ae} (pcf)	K_{pe}	(psf * H)
ESU 2A	0.46	51.02	22.08	1.21	132.63	57.39	618.20	267.51	0.47	51.71	22.38	51.02	51.02	0.46	51.02	22.08	5.62	0.00

Recommended Lateral Earth Pressures

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

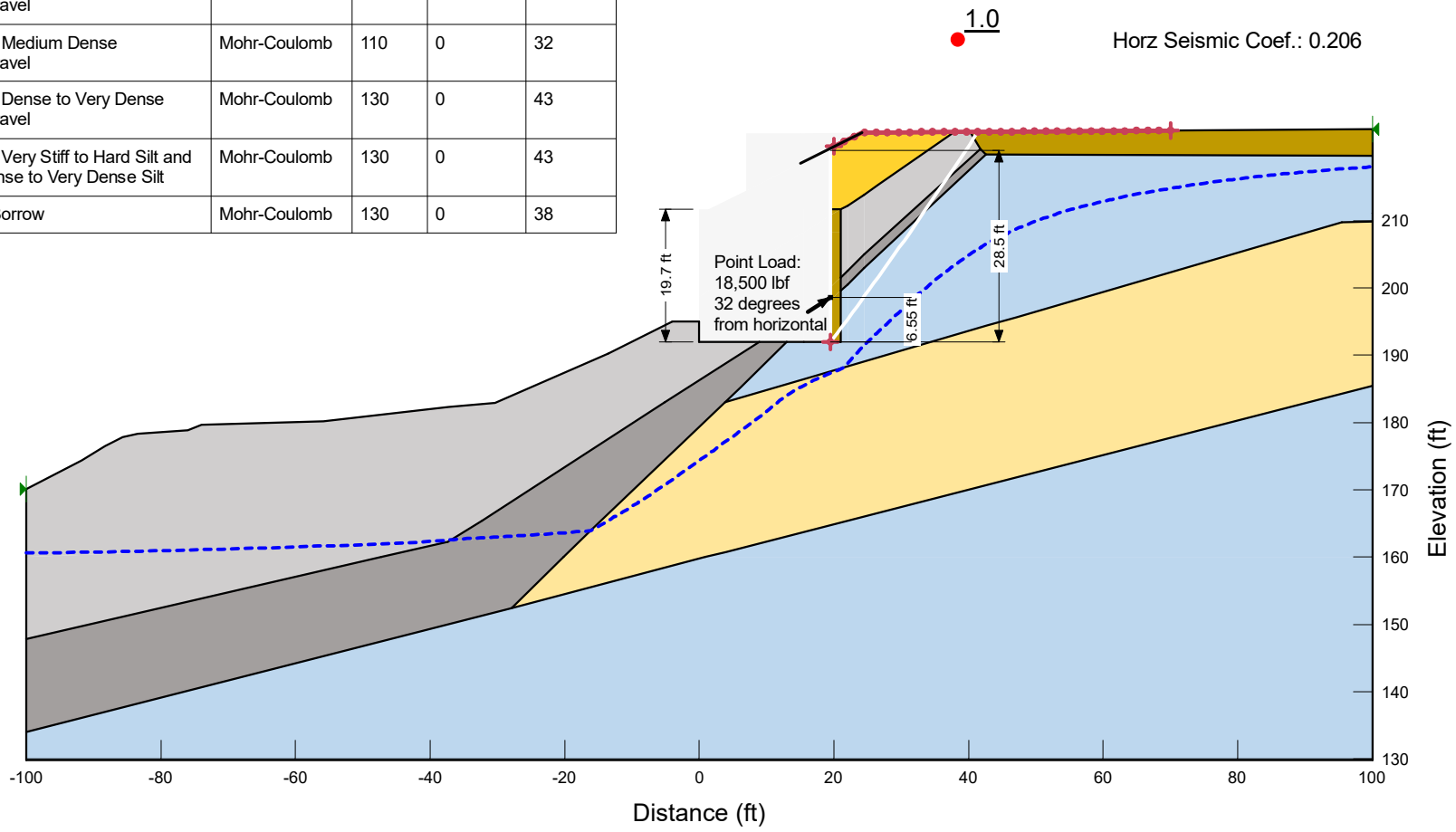
Wall 05.85L-A - Sta. 1+90
LEP - GLE Approach (Spencer, 1/2H)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 09/24/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Wall 05.85L-A - Sta. 1+90
LEP - GLE Approach (Spencer, 1/3H)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 09/24/21

Seismic Earth Pressure Calculation Wall 05.85L-A

Active and seismic earth pressures using the limit equilibrium method outlined in NCHRP Report 611 Section 4.2.1 (Anderson et al., 2008) per AASHTO A11.3.3.

Earth pressures were developed from the bottom of footing to ground surface. Different application location of the force at one-third from the base (1/3H, where H is retained soil height) and at one half from the base were examined to determine the maximum seismic earth pressure. Spencer's methods was used to verify Pa and Pae.

Friction angle of the ESU 2A is used to define the inclination fo the applied point load in the model.

$\phi := 32\ °$ Friction angle of ESU 2A

$P_{AE2} := 18400\ \frac{lbf}{ft}$ Location of force = 1/2H

$P_{AE3} := 18500\ \frac{lbf}{ft}$ Location of force = 1/3H

(See slopeW output attached)

Given: $\gamma := 110\ pcf$ $H := 19.7\ ft$ Height of wall

$k_v := 0$ $k_h := 0.206$ Half of PGA applied for flexible system, PGA reduced to 0.412g for wave scatter effects.

$$K_{AE2} := \frac{P_{AE2} \cdot 2}{\gamma \cdot H^2 \cdot (1 - k_v)} = 0.862$$ Location of force = 1/2H

$$K_{AE3} := \frac{P_{AE3} \cdot 2}{\gamma \cdot H^2 \cdot (1 - k_v)} = 0.867$$ Location of force = 1/3H

Seismic+active earth pressures

$$\max(\gamma \cdot K_{AE2}, \gamma \cdot K_{AE3}) = 95\ \frac{lbf}{ft^3}$$

Sliding Coefficients of Friction

Foundation Soil Type	φ'	Discontinuous Reinforcements
ESU 2A	32	0.62
Common Borrow	32	0.62
Select Borrow	36	0.73
Gravel Borrow	38	0.78

Notes:

Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2

Structural Earth Walls (SEW) are termed Mechanically Stabilized Earth (MSE) walls in AASHTO.

Coefficient of Friction for Discontinuous Reinforcements, e.g., Strips:

Coefficient of friction = 1.0*tan(Phi')

Phi' = lesser of friction angle of foundation soil and friction angle of reinforced fill per AASHTO 11.10.5.3

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for MSE Wall per AASHTO Table 11.5.7-1

where:

ϕ_f = internal friction angle of drained soil (degrees)

V = total vertical force (kips)

LRFD Foundation Design

Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications

Date/Time:	1/11/22 10:37 AM
Project Name:	**I-405/Renton to Bellevue Corridor Widening - Wall 05.85L-A (ESU 2A)**
Project No.:	**00180-366-01**

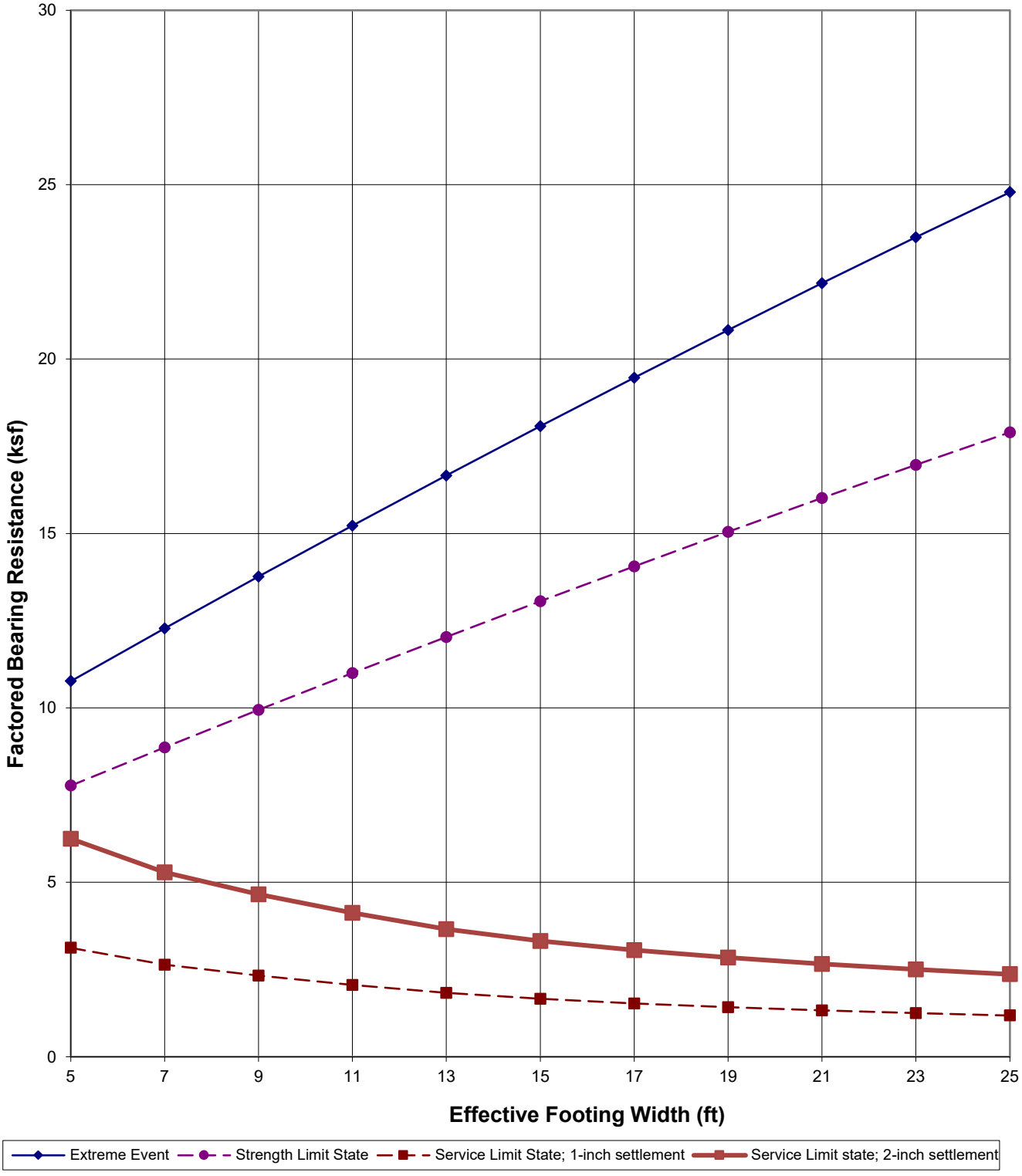
Foundation Soil Conditions	
Unit Weight, γ (pcf)	**110**
Friction angle, Φ (degrees)	**32**
Friction angle, Φ (rad)	0.558
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**3**
Depth to Groundwater, D_w (ft)	**7.2**
Footing Length, L (ft)	**100**
Footing Width, B (ft)	**1**
Poissons Ration, ν	**0.33**
Young's Modulus, E_s (ksf)	**530**

Bearing Capacity Factors	
N_γ	30
N_c	36
N_q	23

Effective Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) for MSE walls (Section 11.5.8 AASHTO)	**Working Bearing Resistance** Resistance Factor (0.65) for MSE walls (Table 11.5.7-1)	Deflection from Elastic Settlement Spreadsheet **1" Deflection**	Deflection from Elastic Settlement Spreadsheet **2" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
5.0	1.0	0.5	1.03	0.98	1.03	12.0	10.8	7.8	3.1	6.3
7.0	1.0	0.5	1.05	0.97	1.04	13.6	12.3	8.9	2.6	5.3
9.0	1.0	0.5	1.06	0.96	1.06	15.3	13.8	9.9	2.3	4.7
11.0	1.0	0.5	1.07	0.96	1.07	16.9	15.2	11.0	2.1	4.1
13.0	1.0	0.5	1.08	0.95	1.08	18.5	16.7	12.0	1.8	3.7
15.0	1.0	0.5	1.10	0.94	1.09	20.1	18.1	13.1	1.7	3.3
17.0	1.0	0.5	1.11	0.93	1.11	21.6	19.5	14.1	1.5	3.1
19.0	1.0	0.5	1.12	0.92	1.12	23.1	20.8	15.0	1.4	2.8
21.0	1.0	0.5	1.14	0.92	1.13	24.6	22.2	16.0	1.3	2.7
23.0	1.0	0.5	1.15	0.91	1.14	26.1	23.5	17.0	1.3	2.5
25.0	1.0	0.5	1.16	0.90	1.16	27.5	24.8	17.9	1.2	2.4

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing are to be excavated.

Wall 05.85L-A Bearing Resistance (ESU 2A)

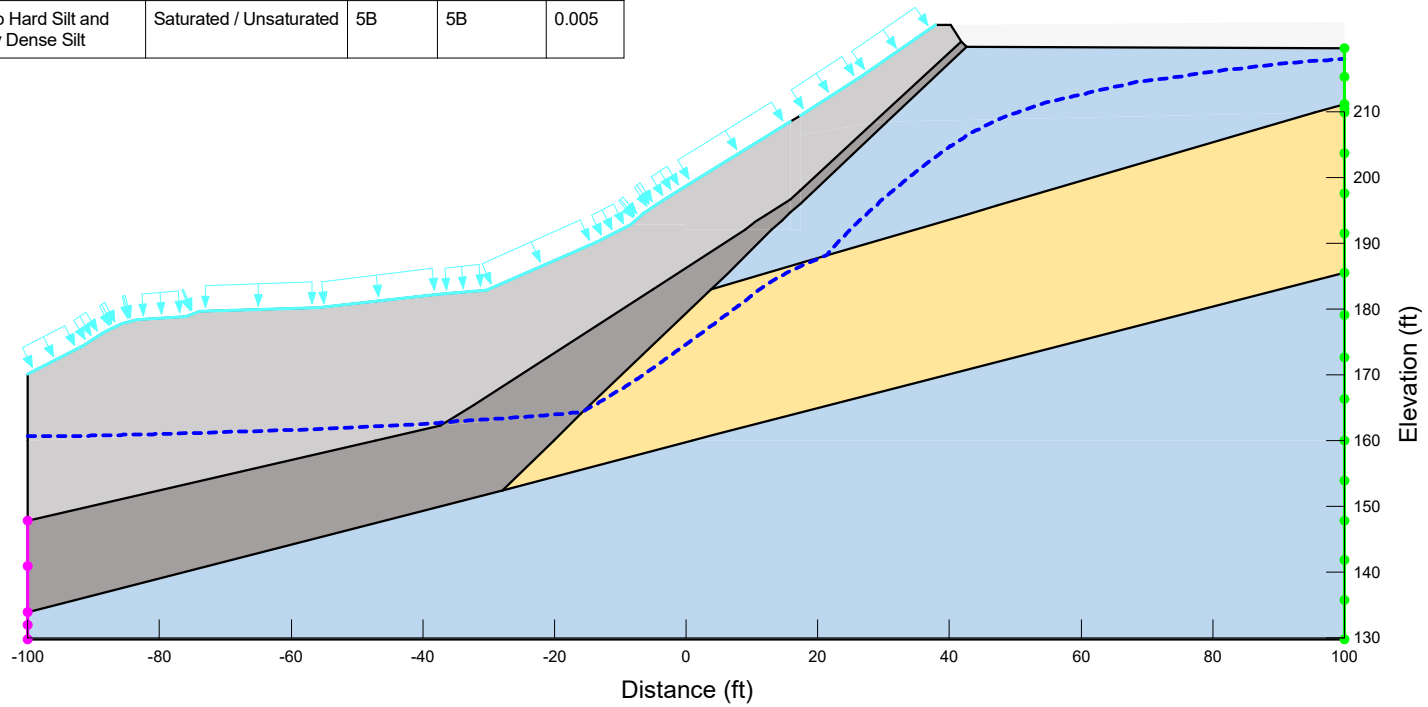


GeoEngineers
Earth Science + Technology

Shallow Foundation Design

Figure 1

Color	Name	Model	Vol. WC. Function	K-Function	Ky'/Kx' Ratio
	ESU 2A Very Loose to Loose Sand/Gravel	Saturated / Unsaturated	2A	2A	0.8
	ESU 2B Medium Dense Sand/Gravel	Saturated / Unsaturated	2B	2B	0.5
	ESU 4B Dense to Very Dense Sand/Gravel	Saturated / Unsaturated	4B	4B	0.025
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Saturated / Unsaturated	5B	5B	0.005



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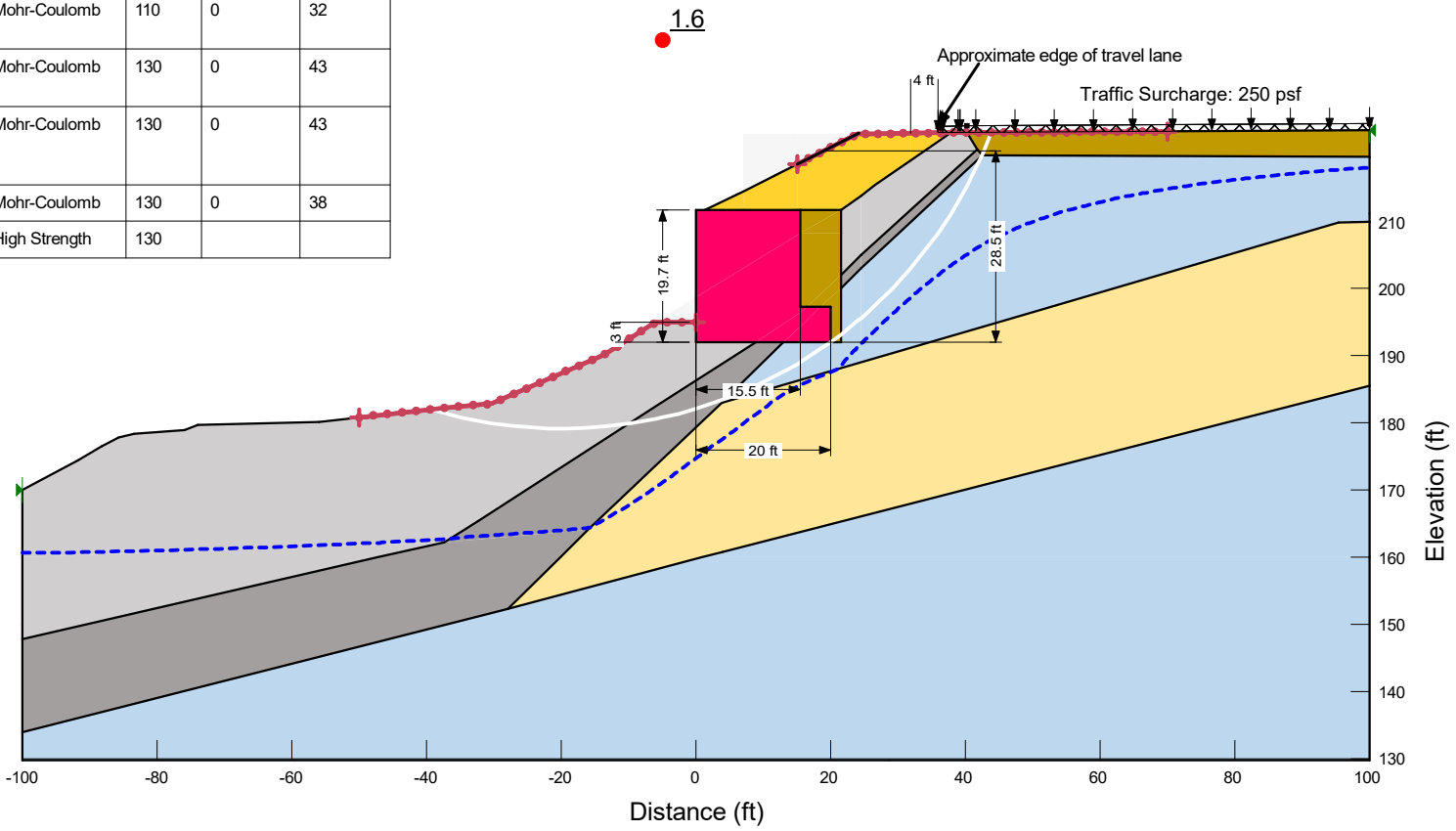
SEW Wall 05.85L-A - Sta. 1+90
Steady State Seepage

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 04/12/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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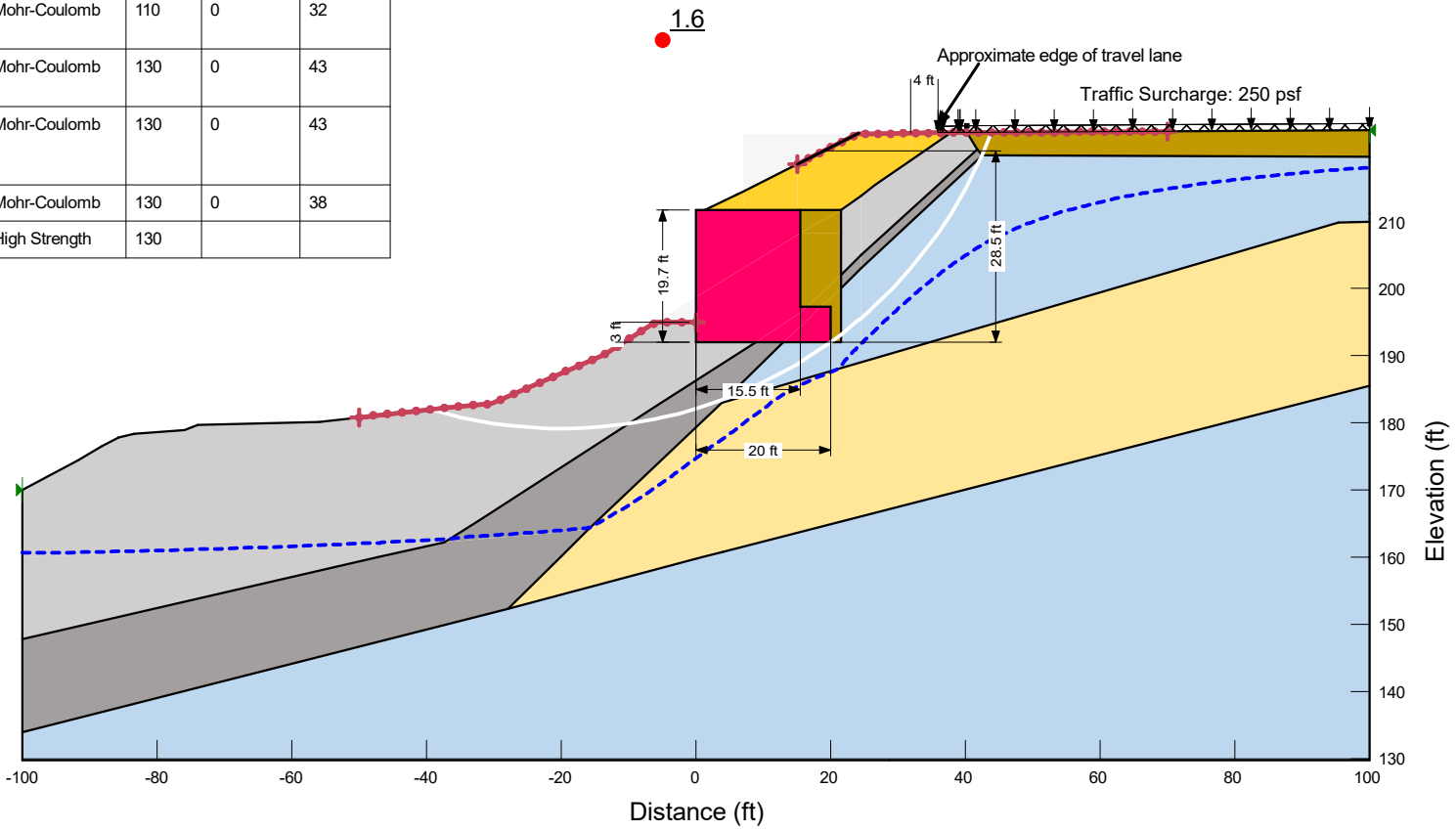
Wall 05.85L-A - Sta. 1+90
Static Global Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 01/17/22

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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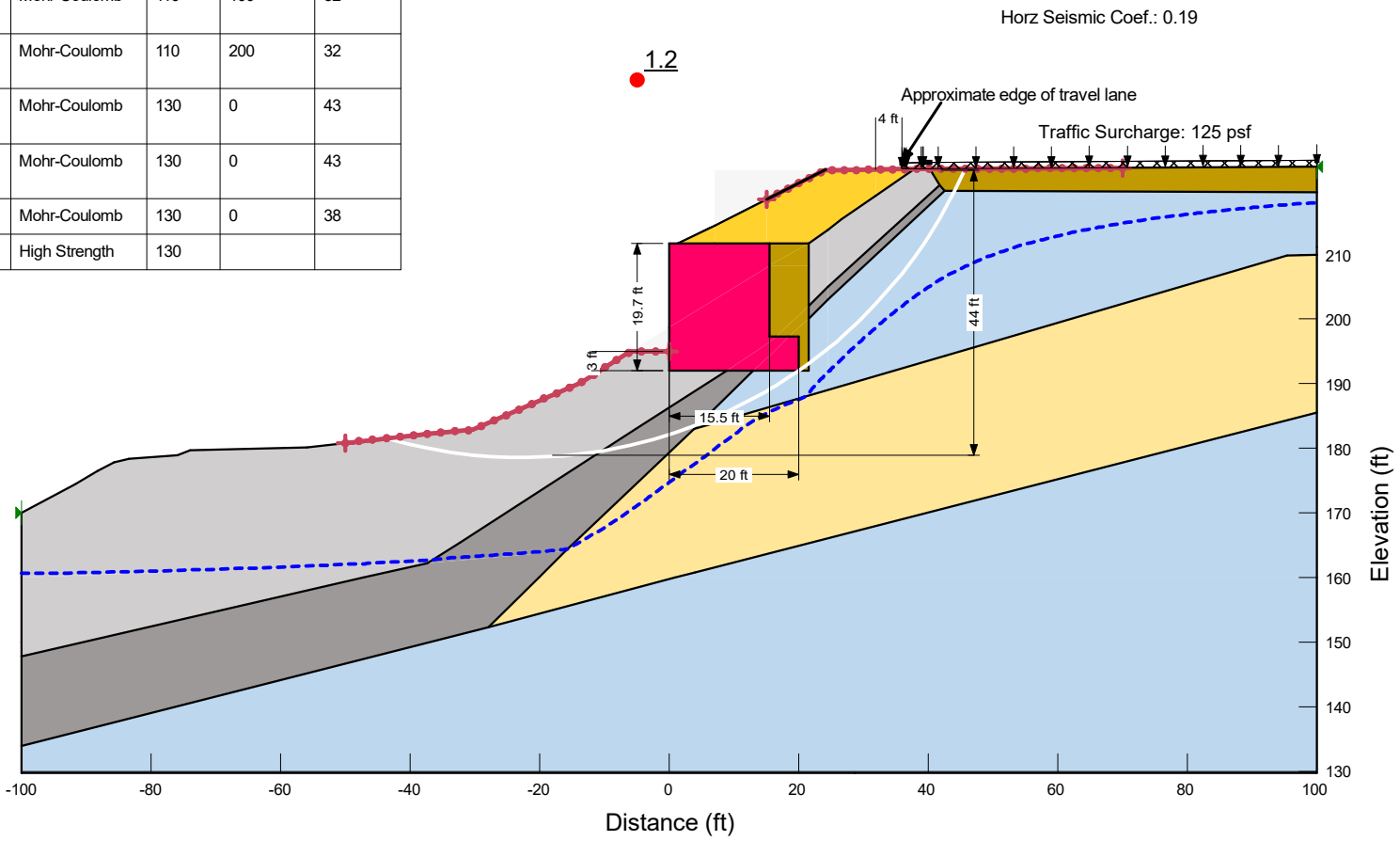
Wall 05.85L-A - Sta. 1+90
Static Global Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 01/17/22

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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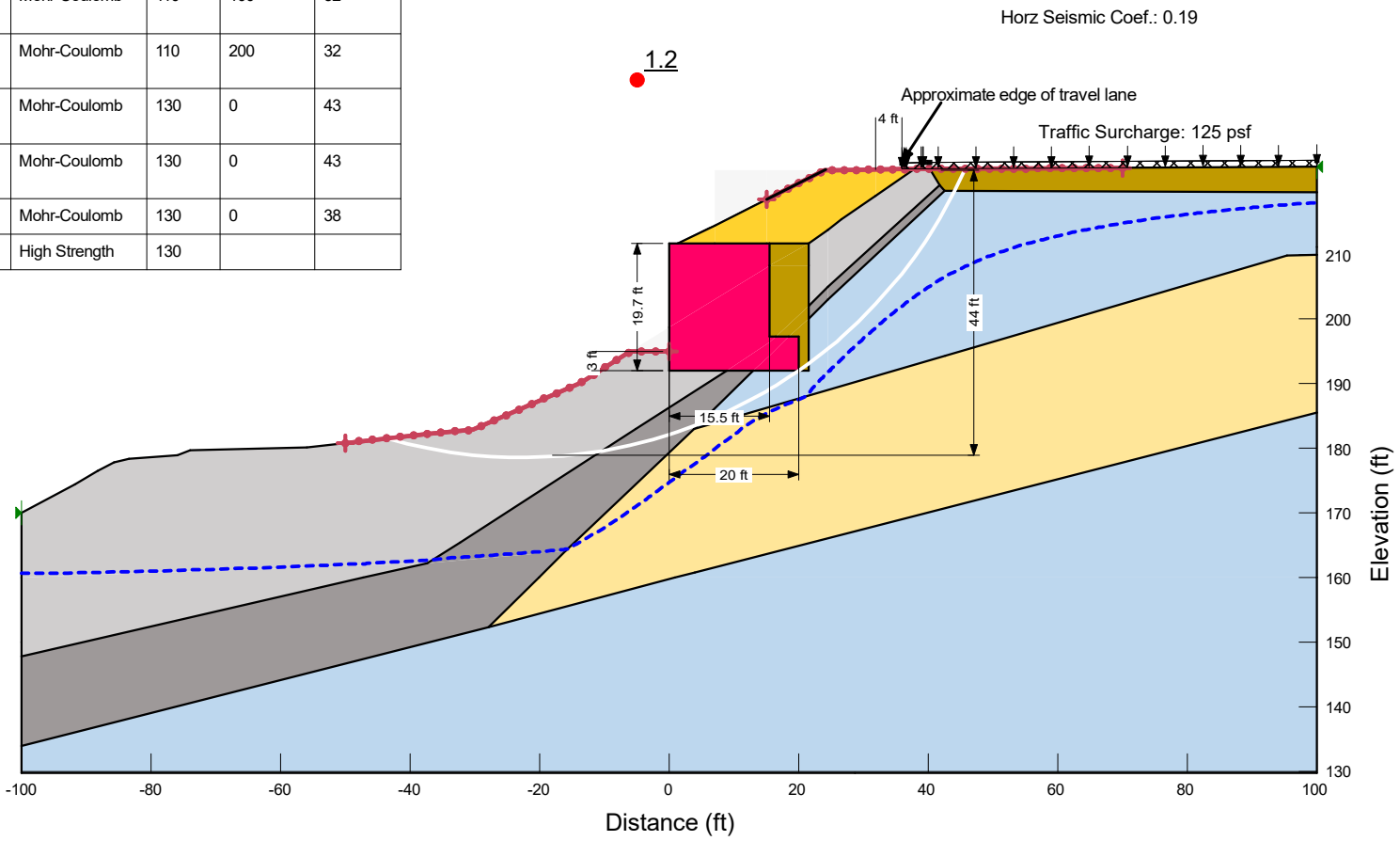
Wall 05.85L-A - Sta. 1+90
Pseudo-Static Global Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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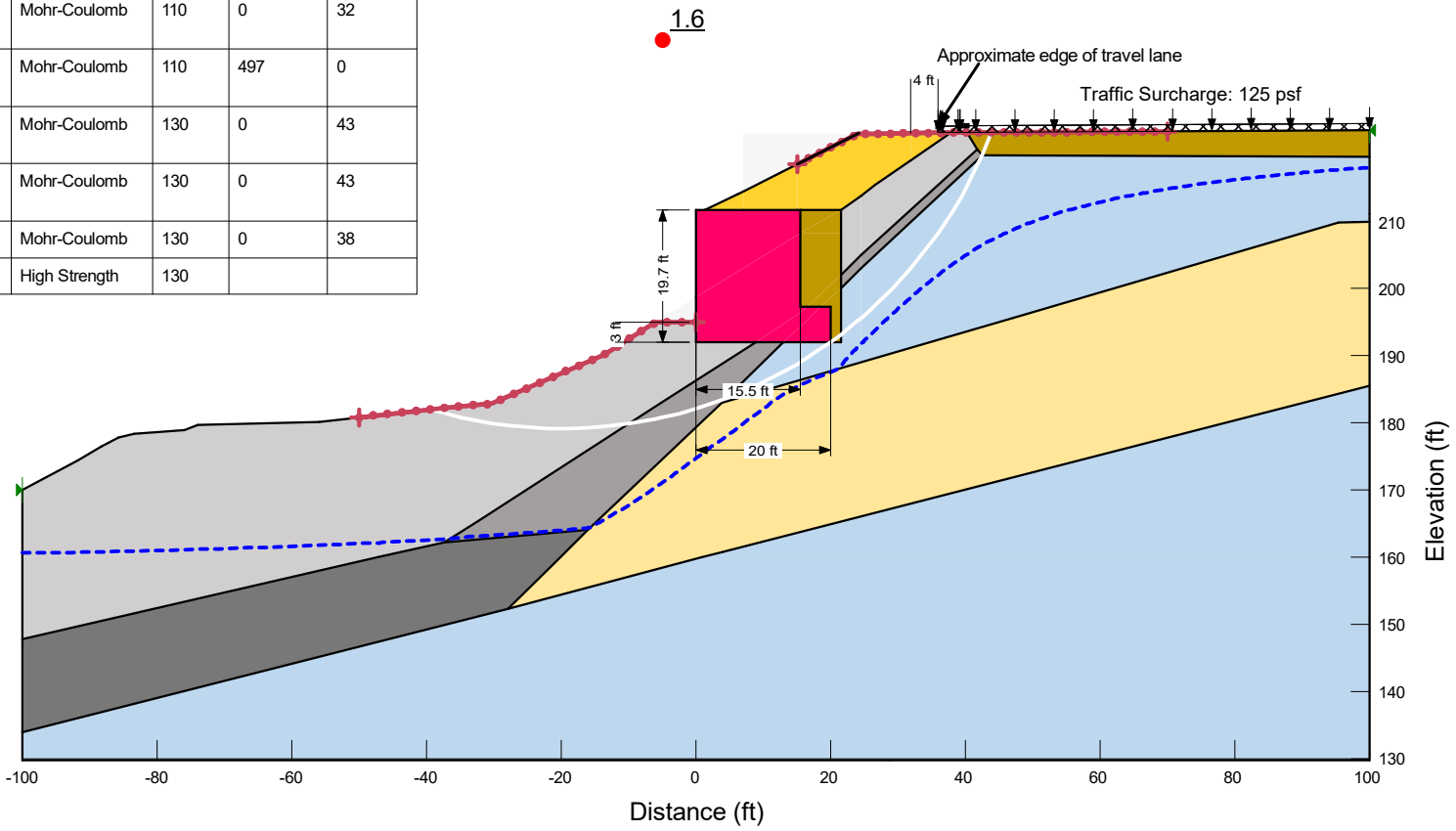
Wall 05.85L-A - Sta. 1+90
Pseudo-Static Global Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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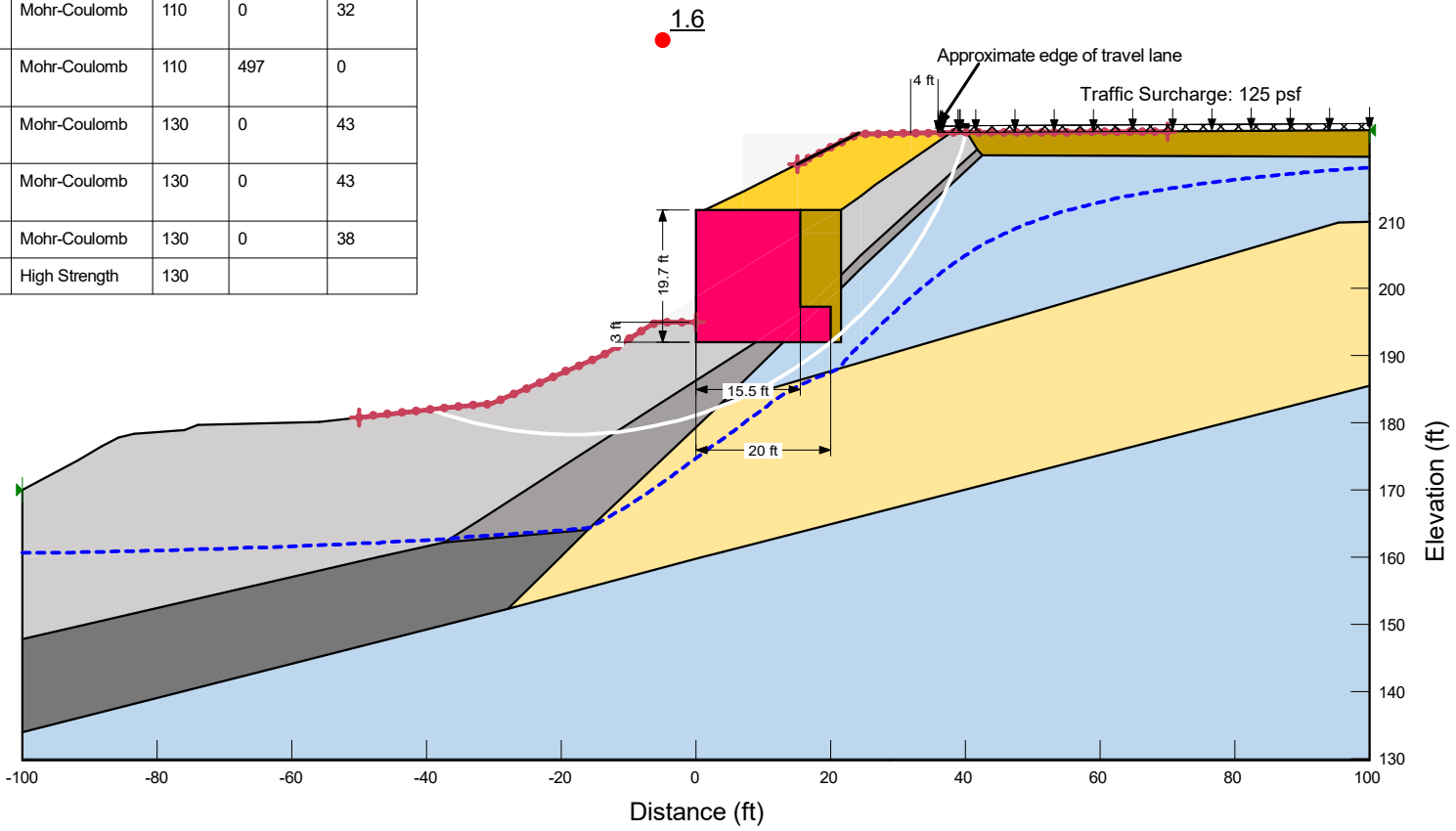
Wall 05.85L-A - Sta. 1+90
Post-Seismic Global Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 01/17/22

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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Wall 05.85L-A - Sta. 1+90
Post-Seismic Global Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

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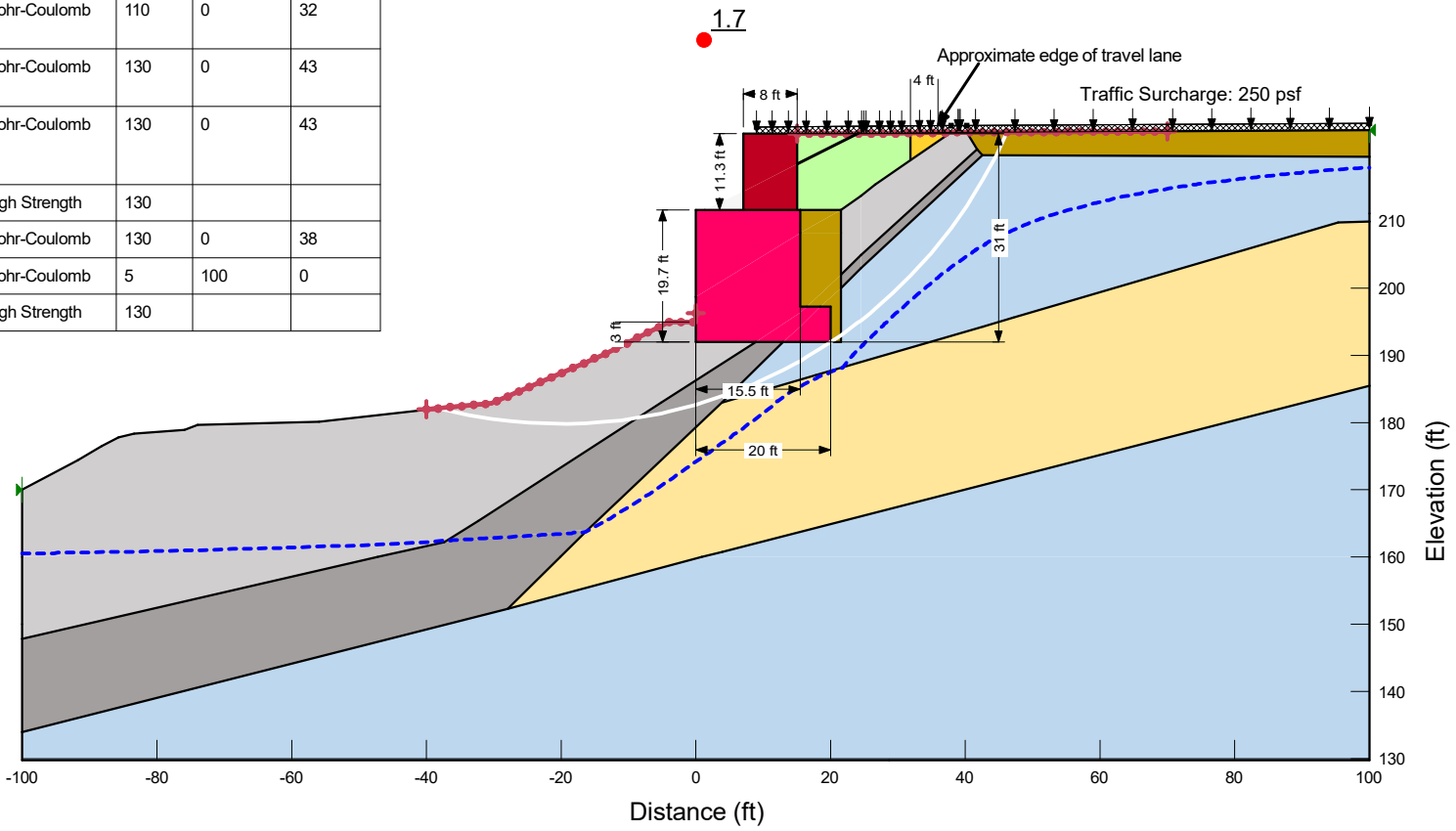
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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Wall 05.85L-A - Sta. 1+90
Static Global Stability + FC Wall (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
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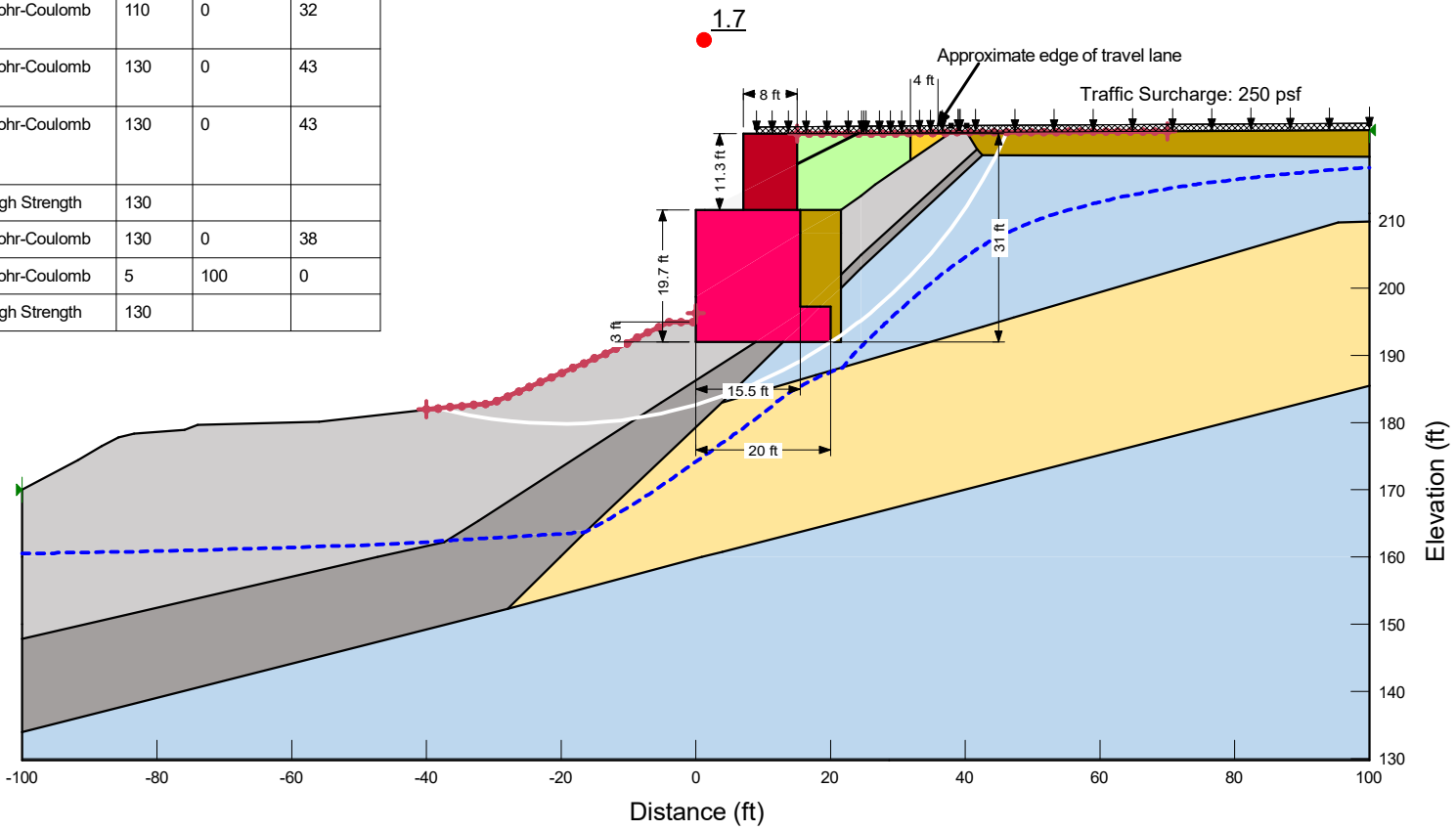
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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Wall 05.85L-A - Sta. 1+90
Static Global Stability + FC Wall (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

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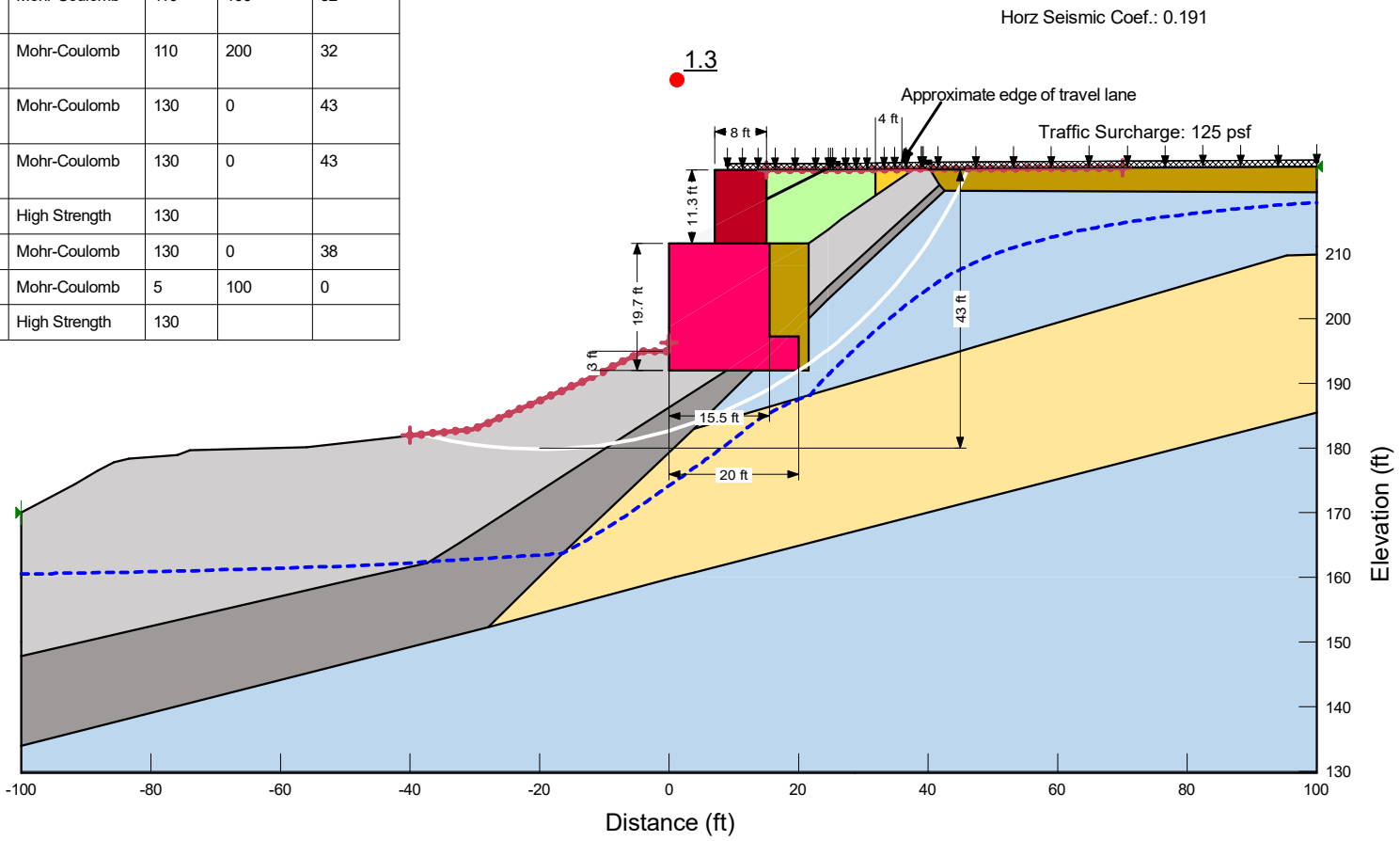
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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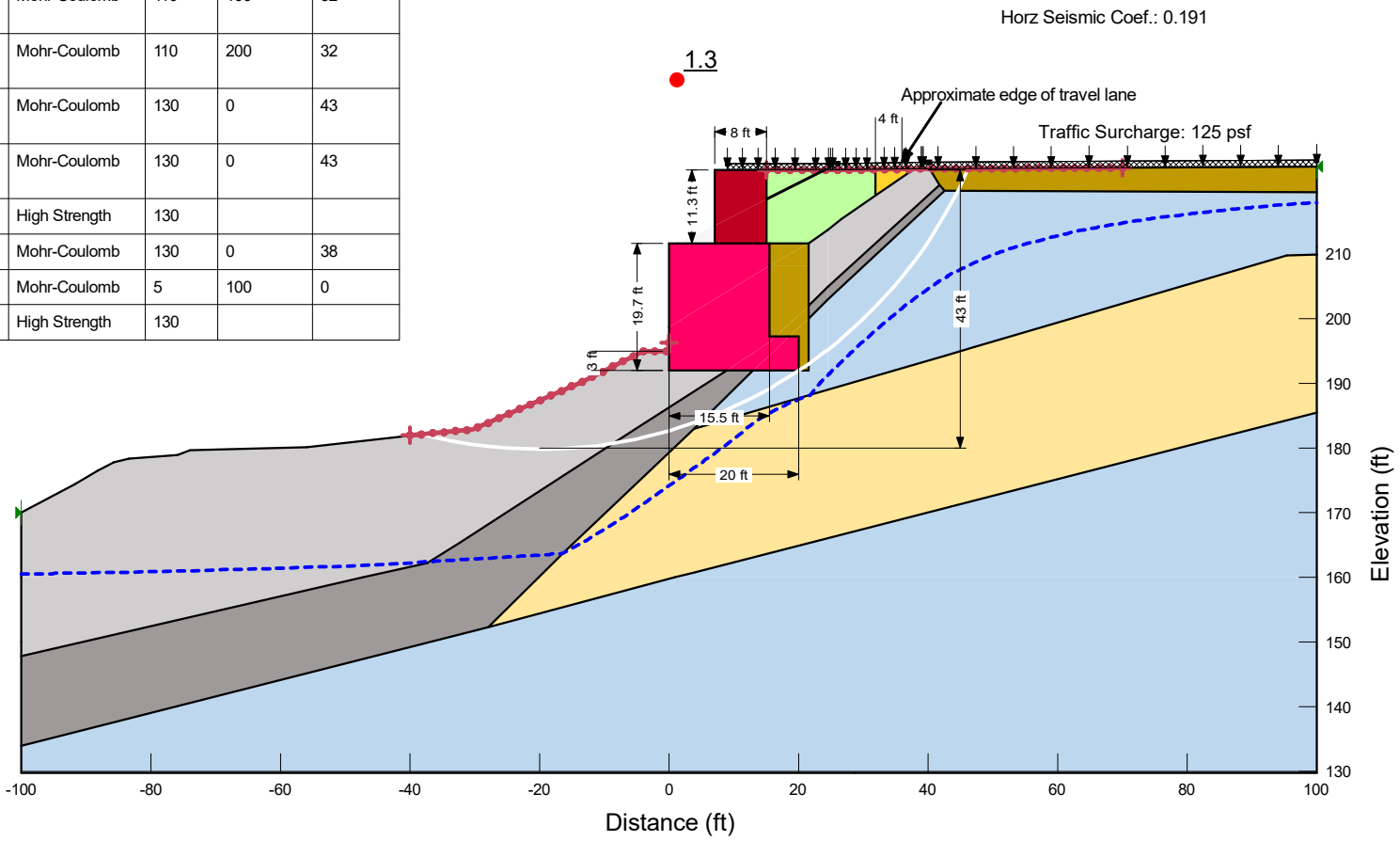
Wall 05.85L-A - Sta. 1+90
Pseudo-Static Global Stability + FC Wall (S)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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Wall 05.85L-A - Sta. 1+90
Pseudo-Static Global Stability + FC Wall (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
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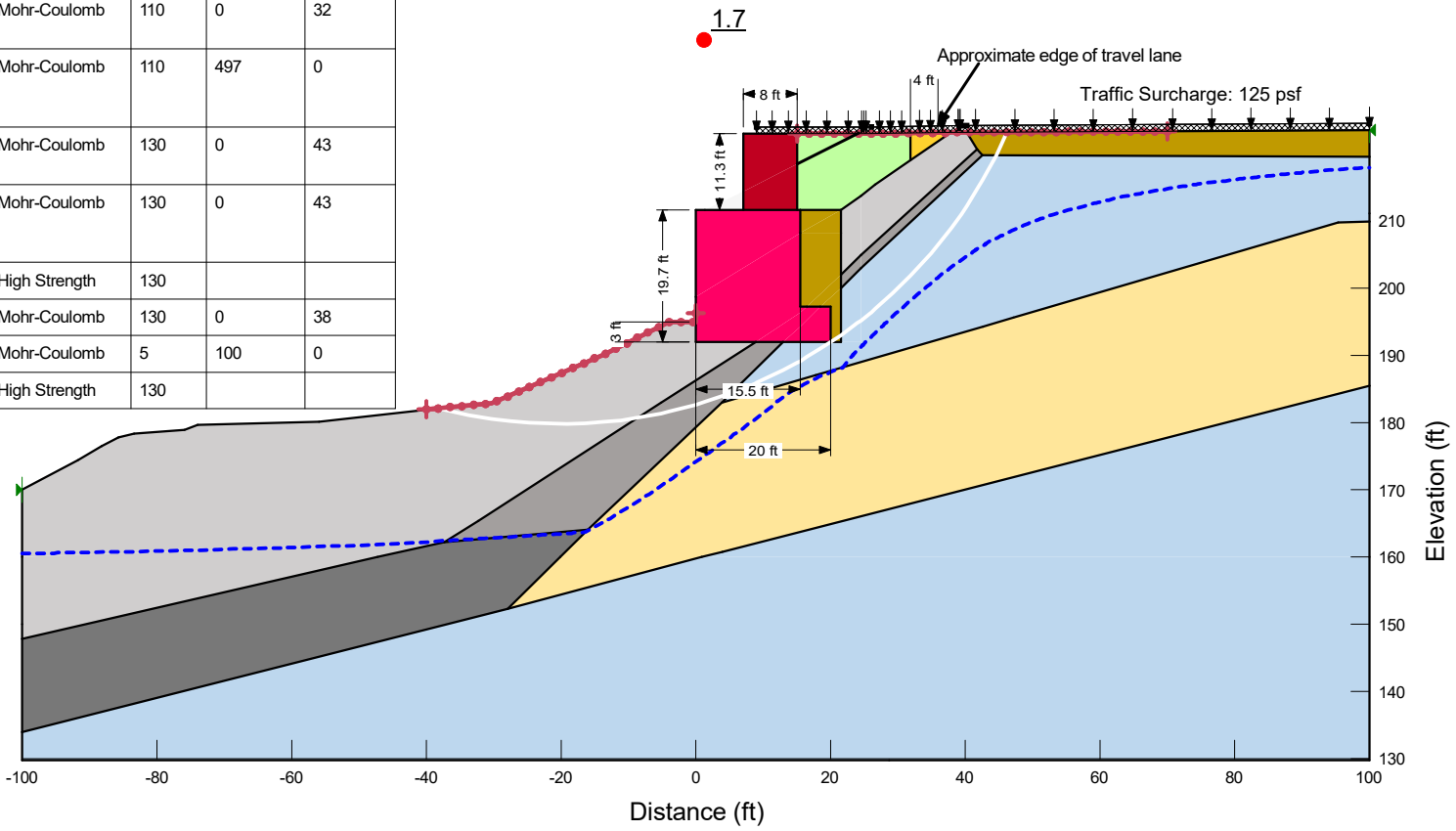
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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Wall 05.85L-A - Sta. 1+90
Post-Seismic Global Stability + FC Wall (S)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
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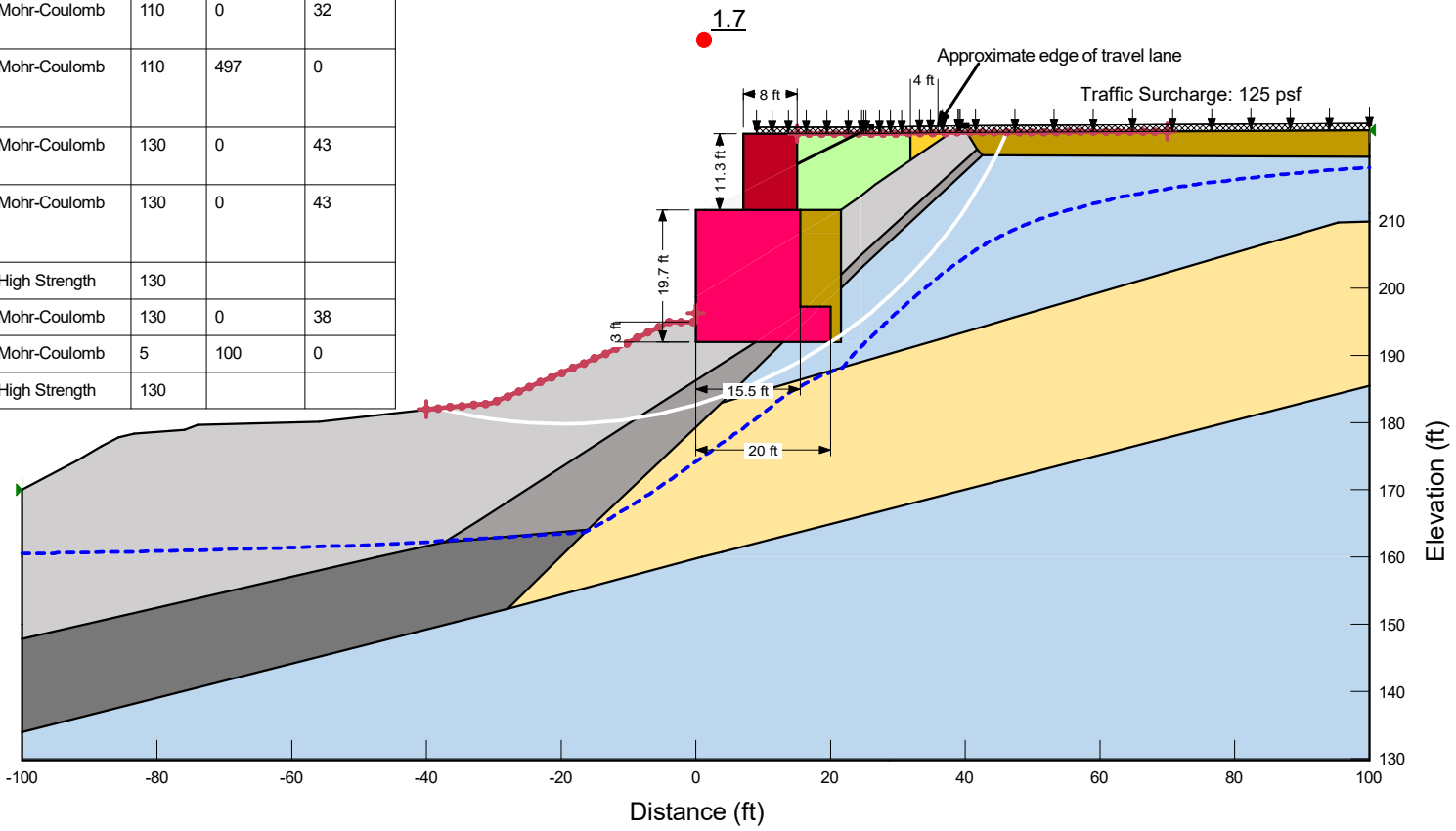

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Wall 05.85L-A - Sta. 1+90
Post-Seismic Global Stability + FC Wall (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

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Calculating MSE Strip Properties for Slope/W (Wall 05.85L-A Sta. 1+90)

For global stability analyses, the MSE wall is modeled as a high strength material and the failure is forced outside of the reinforced zone. To check for compound stability, the high strength material is replaced with gravel borrow and reinforcing strips. The properties of the metal strips are calculated based on FHWA NHI-10-024 and NHI-10-025. The reinforcement properties are converted to per unit width basis, and implemented as a continous layer in Slope/W.

Input Soil Properties:

Backfill meeting WSDOT standard specifications 9-03.14(4), Gravel Borrow for Structural Earth Wall.

$\phi_{gravel} := 38\ \textit{deg}$

Input Strip Properties:

50mm wide and 4mm thick with Grade 65 steel.

$width := 2\ \textit{in}$

$thickness := \frac{5}{32}\ \textit{in}$ Gross thickness (no corrosion)

$f_y := 65.0\ \textit{ksi}$ Yield stress

Calculate Corrosion Reduction:

Calculate new cross-sectional area of steel straps after 75 years of corrosion exposure.

Category	Steel Thickness	Minimum Galvanization Thickness
Strip	< ¼ in. (6.4 mm)	3.4 mils (85 µm)
	> ¼ in. (6.4 mm)	3.9 mils (100 µm)
Wire*	All diameters	3.4 mils (85 µm)
* For bar mats fabricated from uncoated steel wire.		

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate time (in years) to corrode through galvinization.

$0.58 \cdot 2 + 0.16 \cdot \left(t_g - 2\right) = 3.4$

$$t_g := \frac{3.4 - 0.58 \cdot 2}{0.16} + 2 = 16$$

$$t_{75\_years} := thickness - 0.47 \cdot 0.001 \ \frac{in}{yr} \cdot \left(75 - t_g\right) \ yr \cdot 2 = 0.101 \ in$$

$A_c := width \cdot t_{75\_years} = 0.202 \ in^2$ New cross-sectional area after 75 years of corrosion exposure

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements (A)		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact (B)	1.00
	Grid reinforcements (A, C)		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact (B)	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

$\Phi_{static} := 0.75$ $\Phi_{pullout\_static} := 0.9$

$\Phi_{seismic} := 1.0$ $\Phi_{pullout\_seismic} := 1.2$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 19.7\ ft$

Assuming strip layout based on typical RECO A panel, the vertical (s_v) and the horizontal (s_h) spacing of the steel straps within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 1.7 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \end{bmatrix} ft \qquad s_h := \begin{bmatrix} 1.25 \\ 1.25 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \end{bmatrix} ft$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface.

$i := 0 .. \text{length}(s_v) - 1$

Calculate number of elements

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 1.7 \\ 4.1 \\ 6.5 \\ 8.9 \\ 11.3 \\ 13.7 \\ 16.1 \\ 18.5 \end{bmatrix} ft$$

Calculate each strap's vertical elevation, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$depth_i := H_{wall} - elevation_i = \begin{bmatrix} 18 \\ 15.6 \\ 13.2 \\ 10.8 \\ 8.4 \\ 6 \\ 3.6 \\ 1.2 \end{bmatrix} ft$$

Calculate each strap's depth from the ground surface.

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance per unit width of the wall is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) \cdot \frac{width}{s_h}$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal straps in granular backfill.

To select a representative $\phi_{interface}$ that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) \cdot \frac{width}{s_h} = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\frac{\Phi_{pullout} \cdot F \cdot width}{s_h}\right)$$

Calculate Pullout Resistance Factor F*:

In the absence of site-specific pullout testing data, it is reasonable to use the semi-empirical relationships described in the following paragraphs in conjunction with the standard specifications for reinforced fill to provide a conservative evaluation of pullout resistance.

For steel ribbed reinforcement, the Pullout Resistance Factor F* is commonly taken as:

$$F^* = \tan\rho = 1.2 + \log C_u \text{ at the top of the structure} = 2.0 \text{ maximum} \quad (3\text{-}4)$$

$$F^* = \tan\phi \text{ at a depth of 20 ft (6 m) and below} \quad (3\text{-}5)$$

where C_u is the uniformity coefficient of the backfill (D_{60}/D_{10}). **If the specific C_u for the wall backfill is unknown at design time, a $C_u = 4$ should be assumed (i.e., F* = 1.8 at the top of the wall) for reinforced fills meeting the requirements of Section 3.1 of this chapter.**

$C_u := 6.3$ Backfill used will need to meet gradation assumed

$F_{max} := 1.2 + \log(C_u) = 1.999$

$$F_i := \begin{cases} \text{if } depth_i < 20\ ft \\ \quad \left(F_{max} - \tan(\phi_{gravel})\right) \cdot \left(\frac{(20\ ft - depth_i)}{20\ ft}\right) + \tan(\phi_{gravel}) \\ \text{else} \\ \quad \tan(\phi_{gravel}) \end{cases}$$

$$F = \begin{bmatrix} 0.9 \\ 1.05 \\ 1.2 \\ 1.34 \\ 1.49 \\ 1.63 \\ 1.78 \\ 1.93 \end{bmatrix}$$

Calculated F* for each row of reinforcement.
Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\frac{\Phi_{pullout\_static} \cdot F \cdot width}{s_h}\right) = \begin{bmatrix} 6.2 \\ 7.2 \\ 4.1 \\ 4.6 \\ 5.1 \\ 5.6 \\ 6.1 \\ 6.6 \end{bmatrix} \ deg$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\frac{\Phi_{pullout\_seismic} \cdot F \cdot width}{s_h}\right) = \begin{bmatrix} 8.2 \\ 9.5 \\ 5.5 \\ 6.1 \\ 6.8 \\ 7.4 \\ 8.1 \\ 8.8 \end{bmatrix} \ deg$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{al\_static} := \Phi_{static} \cdot f_y \ A_c = 9.83 \ kip$$

$$T_{al\_seismic} := \Phi_{seismic} \cdot f_y \ A_c = 13.1 \ kip$$

Slope/W does not have strap reinforcement inputs. Therefore, the tensile strength of the straps were modeled as continuous reinforcement. The calculated allowable tensile strap capacity was converted to a continuous reinforcement tensile capcity by distributing the capacity over the tributary width.

$$T_{al\_static\_row} := \frac{T_{al\_static}}{s_h} = \begin{bmatrix} 7.86 \\ 7.86 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \end{bmatrix} \frac{kip}{ft}$$

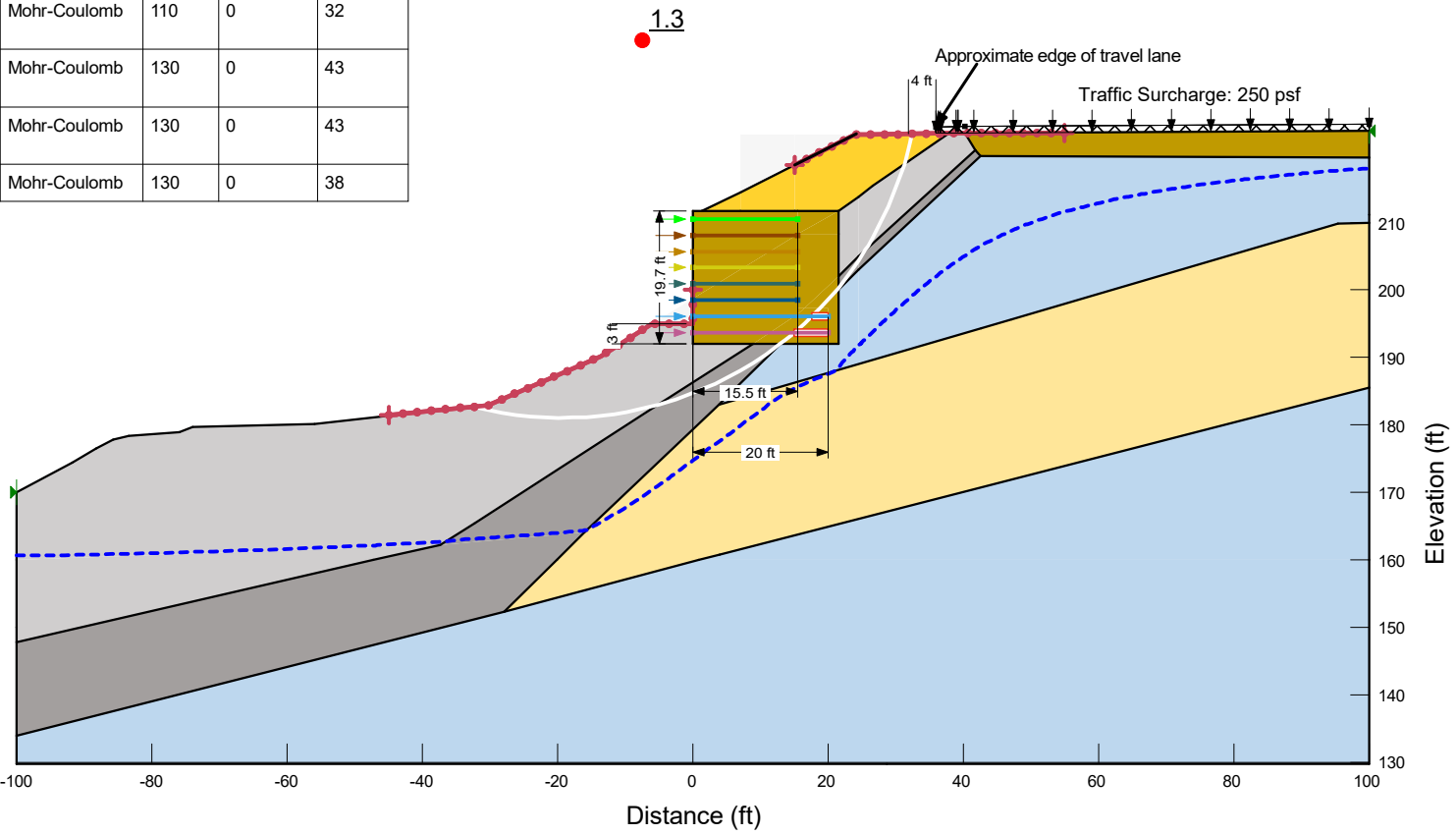
Static tensile capacity Slope/W inputs for each wall reinforcement row. Top row of the matrix represents the bottowm row of the SE Wall reinforcement.

$$T_{al\_seismic\_row} := \frac{T_{al\_seismic}}{s_h} = \begin{bmatrix} 10.48 \\ 10.48 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \end{bmatrix} \frac{kip}{ft}$$

Seismic tensile capacity Slope/W inputs for each wall reinforcement row. Top row of the matrix represents the bottowm row of the SE Wall reinforcement.

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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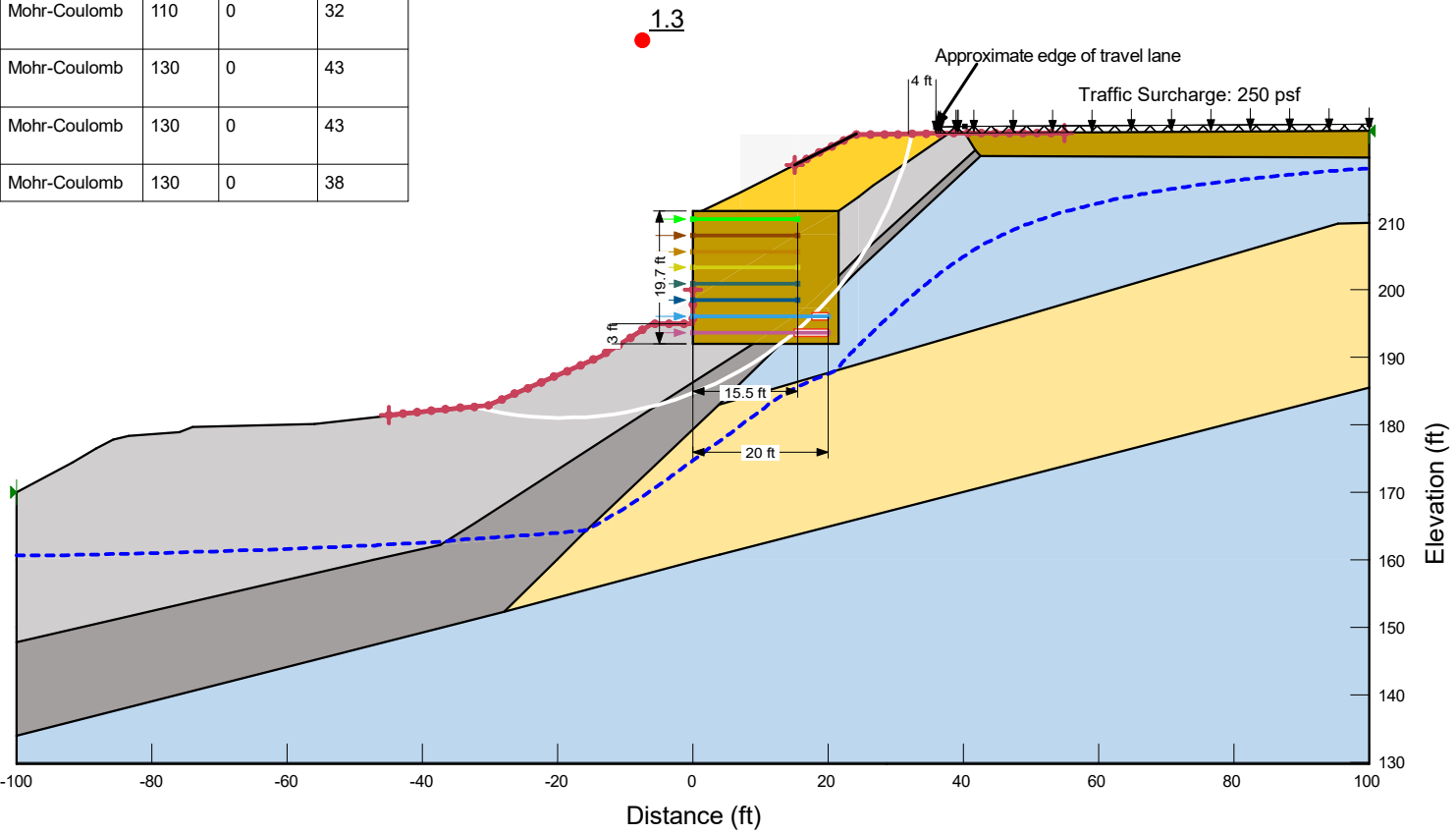
Wall 05.85L-A - Sta. 1+90
Static Compound Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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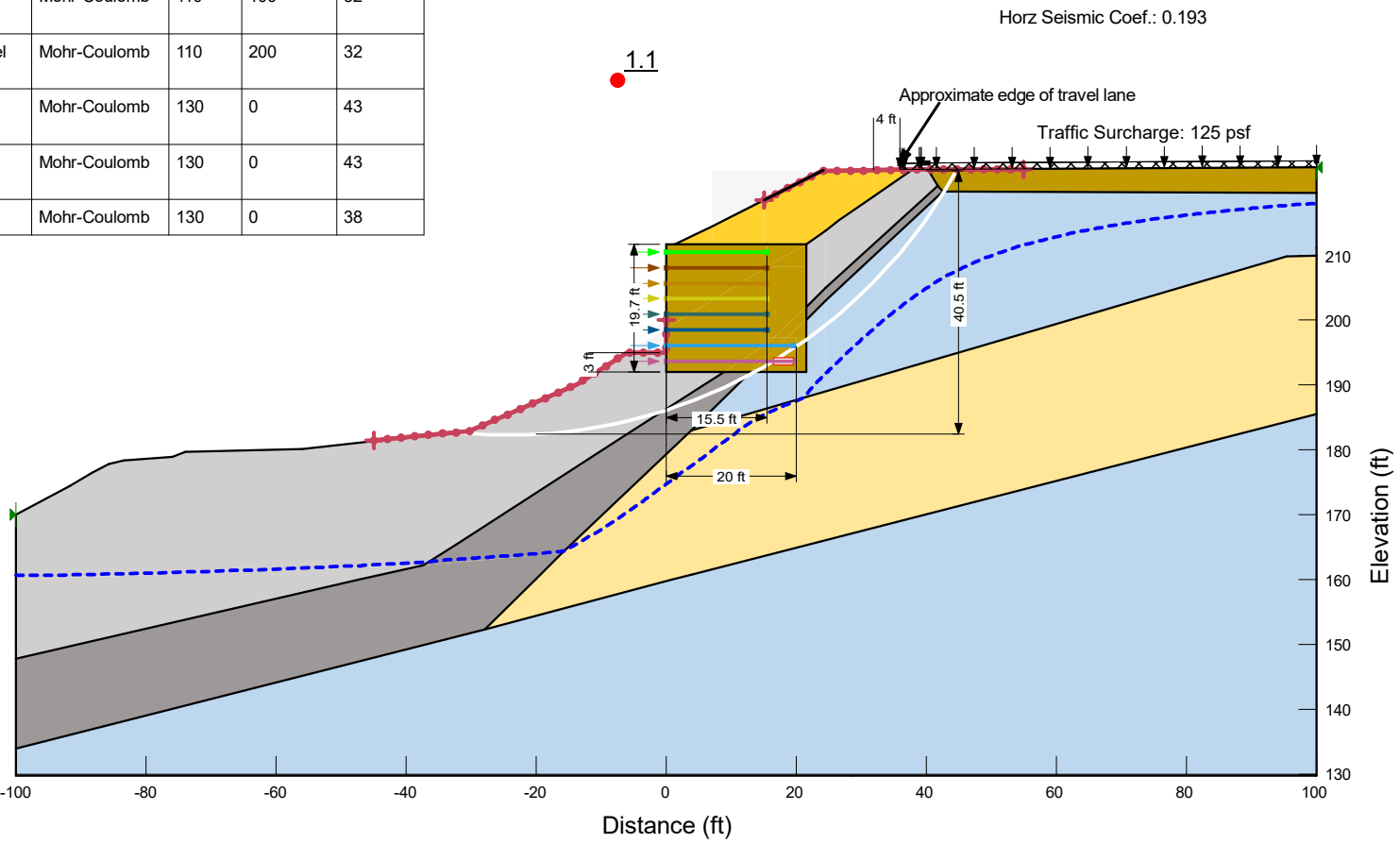
Wall 05.85L-A - Sta. 1+90
Static Compound Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (EQ)	8.8	5,240
	Row 2 (EQ)	8.1	5,240
	Row 3 (EQ)	7.4	5,240
	Row 4 (EQ)	6.8	5,240
	Row 5 (EQ)	6.1	5,240
	Row 6 (EQ)	5.5	5,240
	Row 7 (4 straps)(EQ)	9.5	10,480
	Row 8 (4 straps)(EQ)	8.2	10,480



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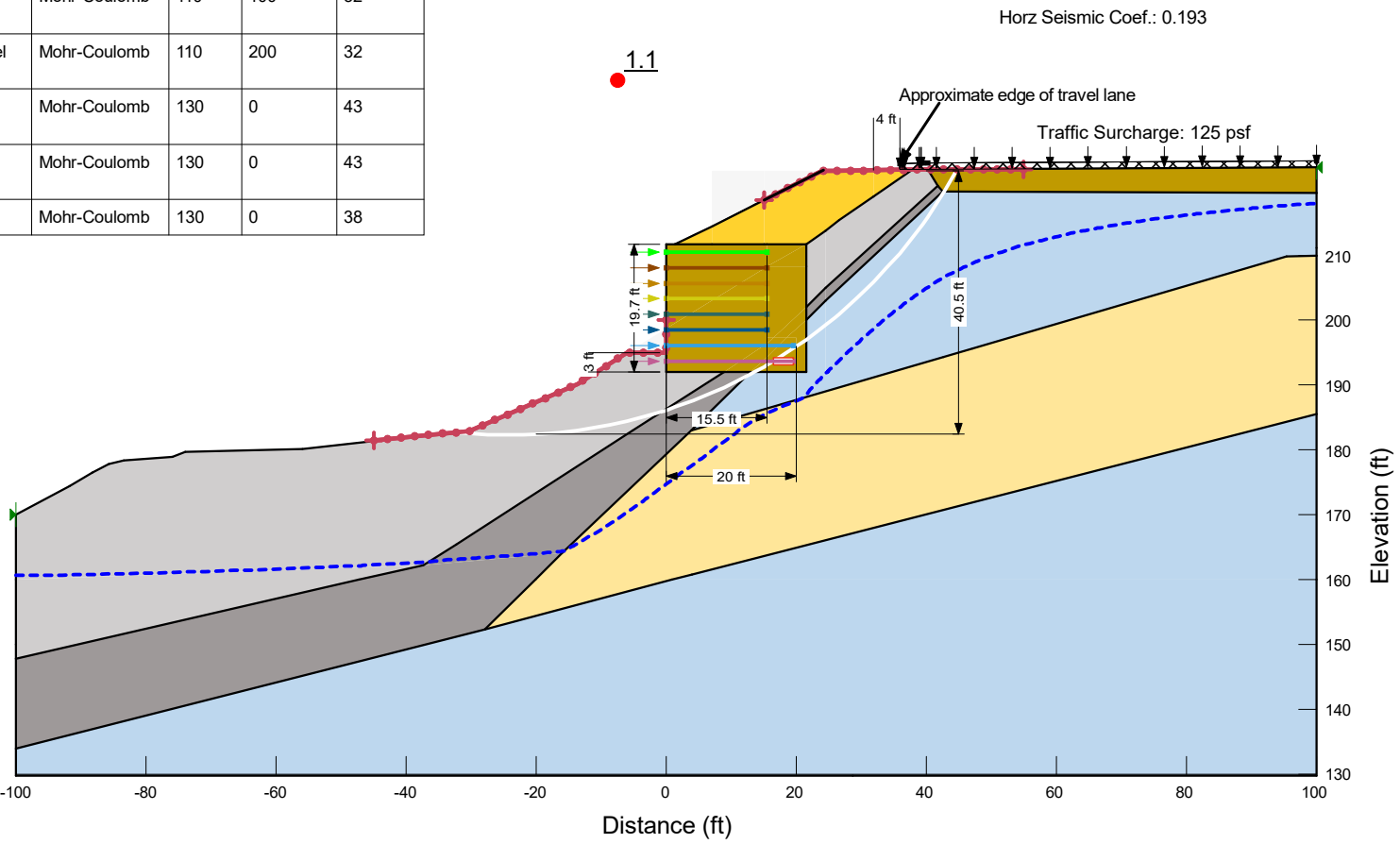
Wall 05.85L-A - Sta. 1+90
Pseudo-Static Compound Stability (Spencer)
I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (EQ)	8.8	5,240
	Row 2 (EQ)	8.1	5,240
	Row 3 (EQ)	7.4	5,240
	Row 4 (EQ)	6.8	5,240
	Row 5 (EQ)	6.1	5,240
	Row 6 (EQ)	5.5	5,240
	Row 7 (4 straps)(EQ)	9.5	10,480
	Row 8 (4 straps)(EQ)	8.2	10,480



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Wall 05.85L-A - Sta. 1+90
Pseudo-Static Compound Stability (M-P)
I-405/Renton to Bellevue Corridor Widening
King County, Washington

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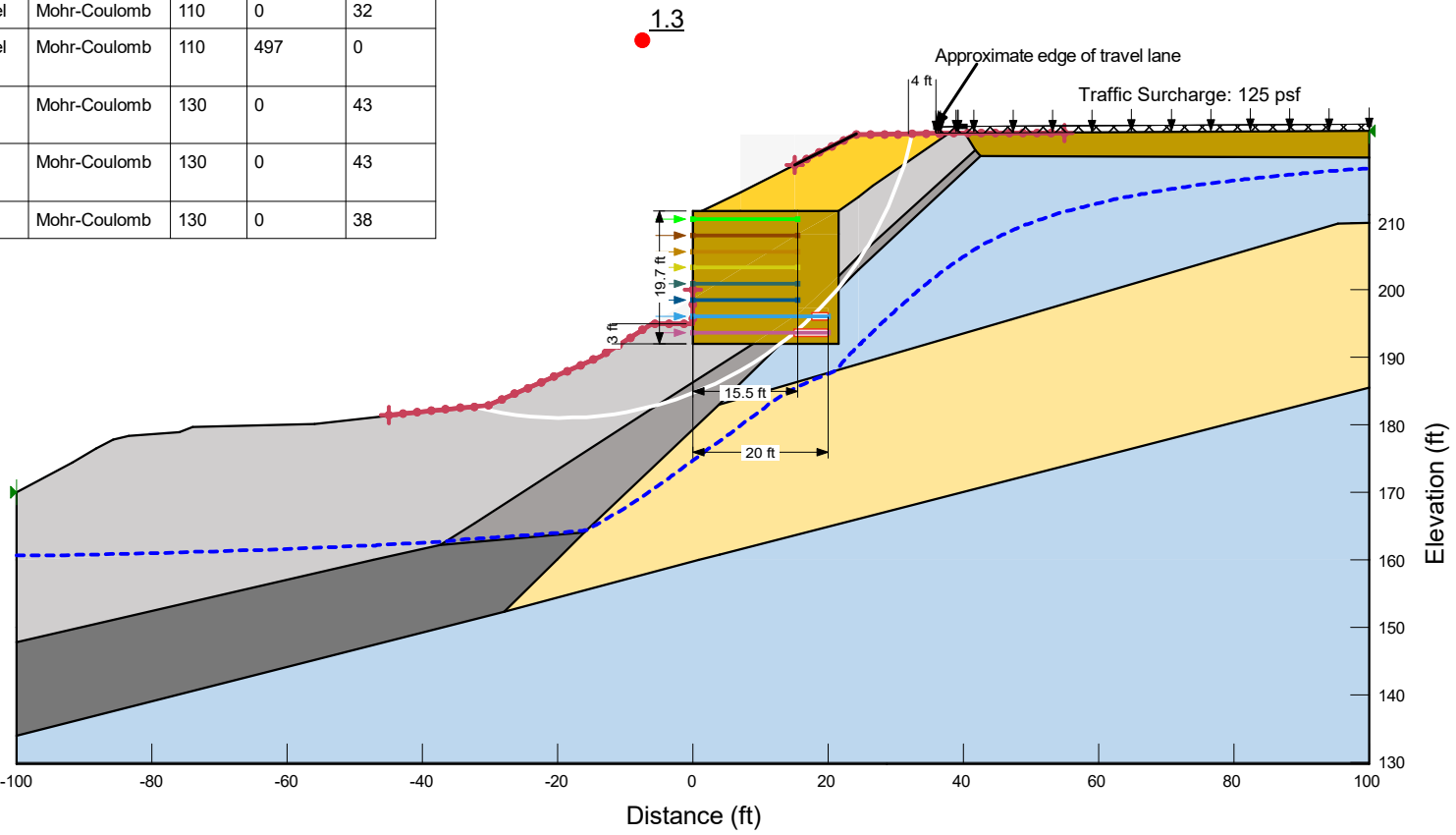
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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Wall 05.85L-A - Sta. 1+90
Post-Seismic Compound Stability (Spencer)
I-405/Renton to Bellevue Corridor Widening
King County, Washington

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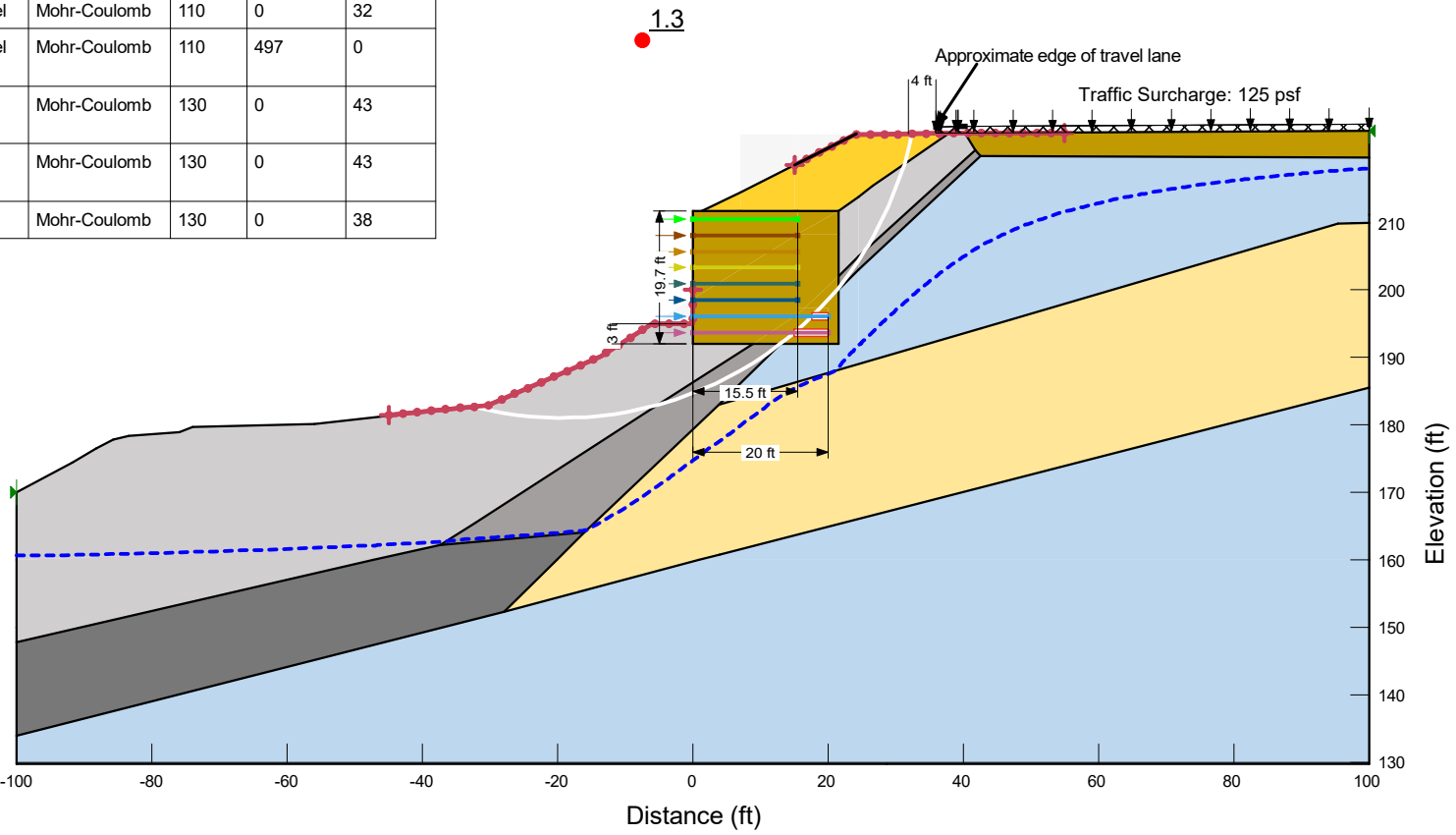
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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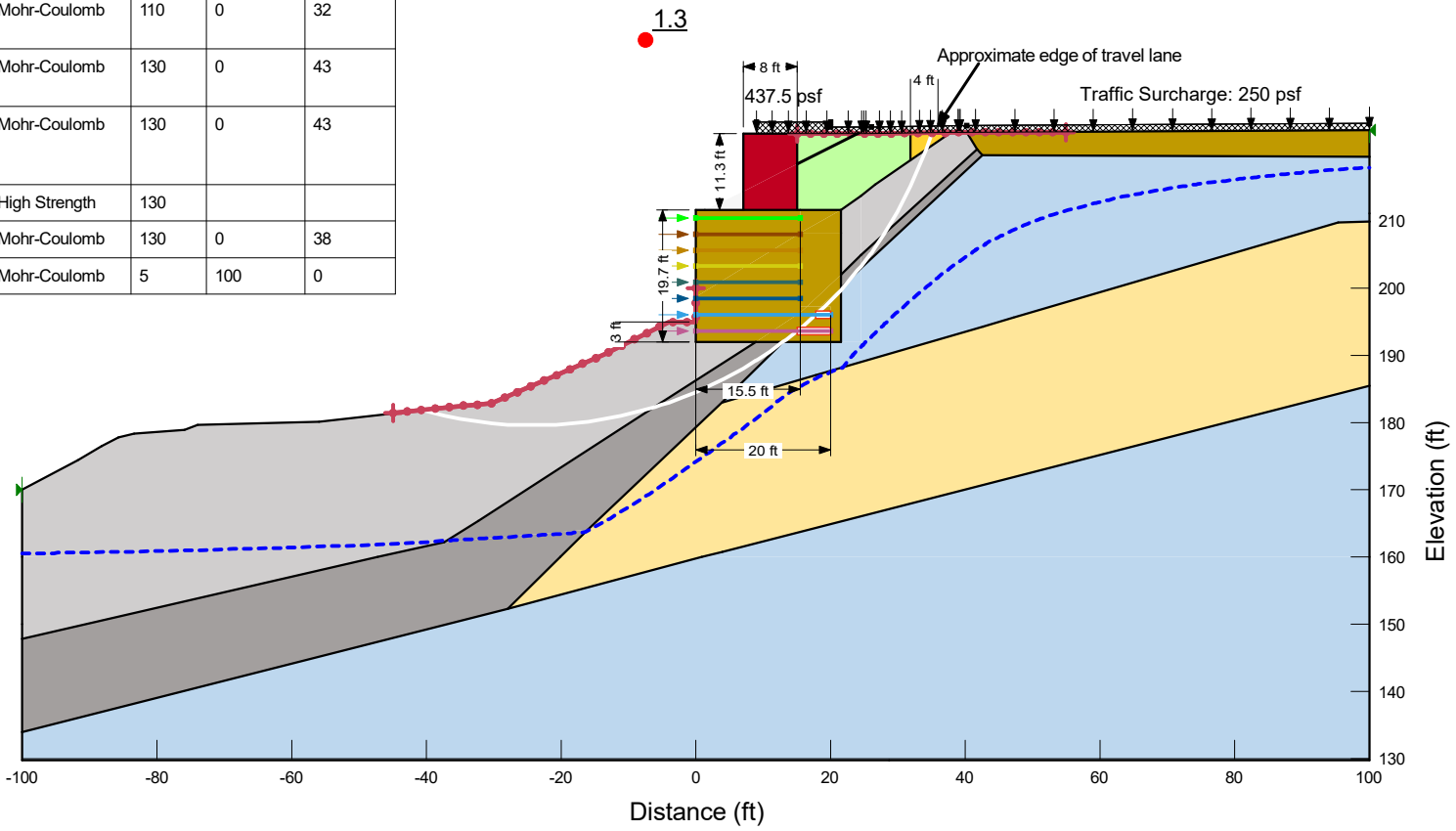
Wall 05.85L-A - Sta. 1+90
Post-Seismic Compound Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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Wall 05.85L-A - Sta. 1+90
Static Compound Stability + FC Wall (Spencer)

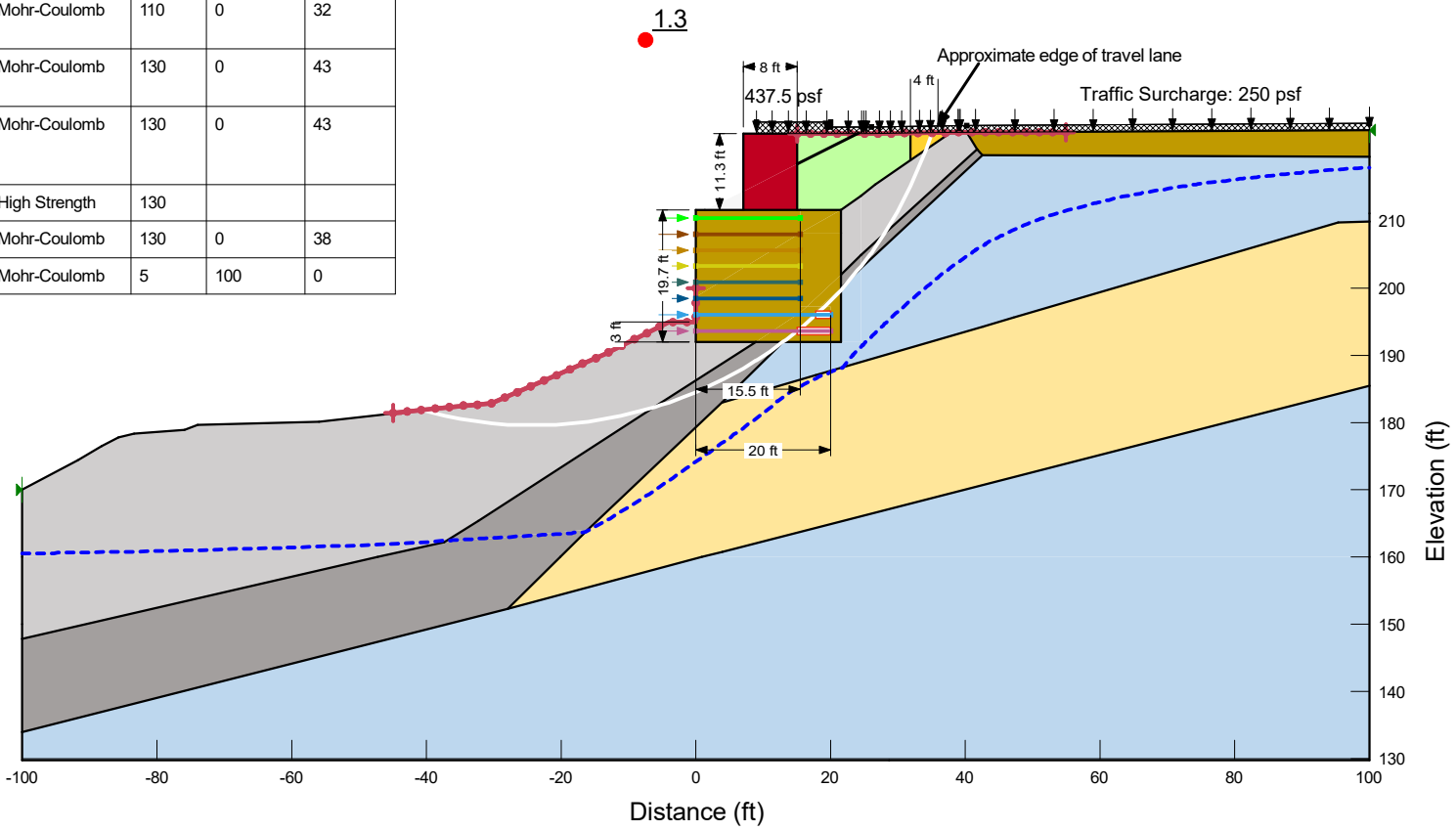
I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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Wall 05.85L-A - Sta. 1+90
Static Compound Stability + FC Wall (M-P)

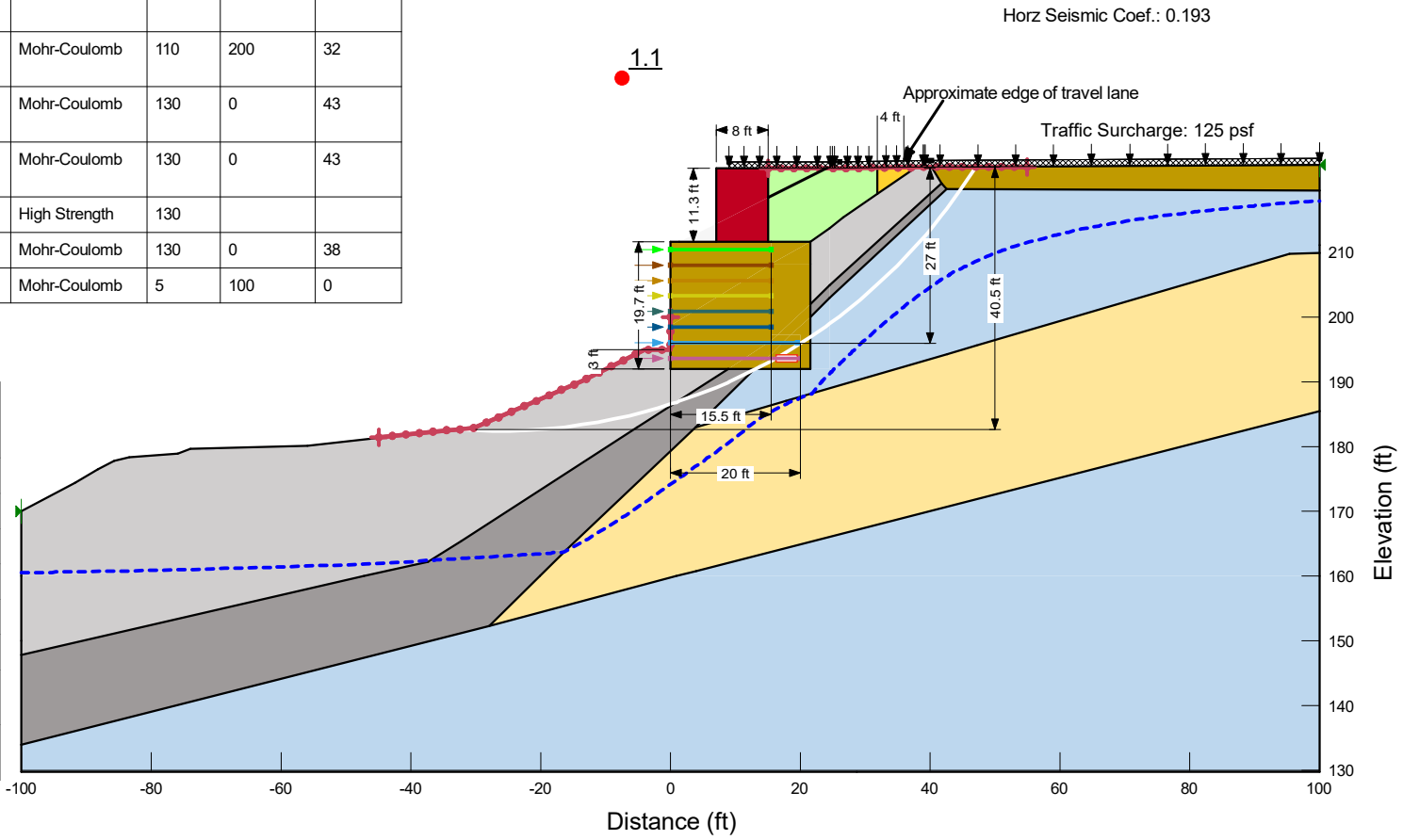
I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (EQ)	8.8	5,240
	Row 2 (EQ)	8.1	5,240
	Row 3 (EQ)	7.4	5,240
	Row 4 (EQ)	6.8	5,240
	Row 5 (EQ)	6.1	5,240
	Row 6 (EQ)	5.5	5,240
	Row 7 (4 straps)(EQ)	9.5	10,480
	Row 8 (4 straps)(EQ)	8.2	10,480



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Wall 05.85L-A - Sta. 1+90
Pseudo-Static Compound Stability + FC Wall (S)

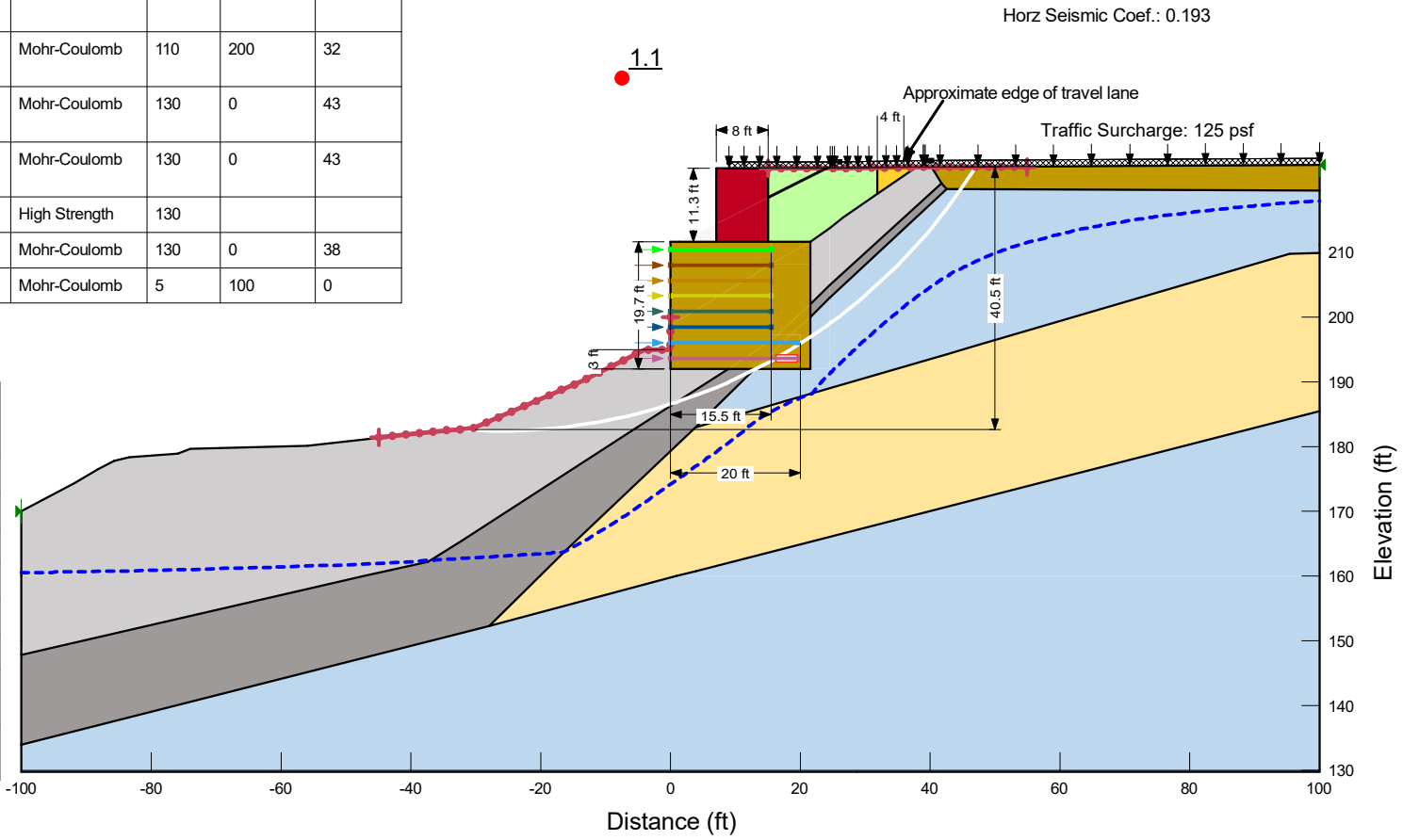
I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	100	32
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	110	200	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (EQ)	8.8	5,240
	Row 2 (EQ)	8.1	5,240
	Row 3 (EQ)	7.4	5,240
	Row 4 (EQ)	6.8	5,240
	Row 5 (EQ)	6.1	5,240
	Row 6 (EQ)	5.5	5,240
	Row 7 (4 straps)(EQ)	9.5	10,480
	Row 8 (4 straps)(EQ)	8.2	10,480



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Wall 05.85L-A - Sta. 1+90
Pseudo-Static Compound Stability+FC Wall (M-P)

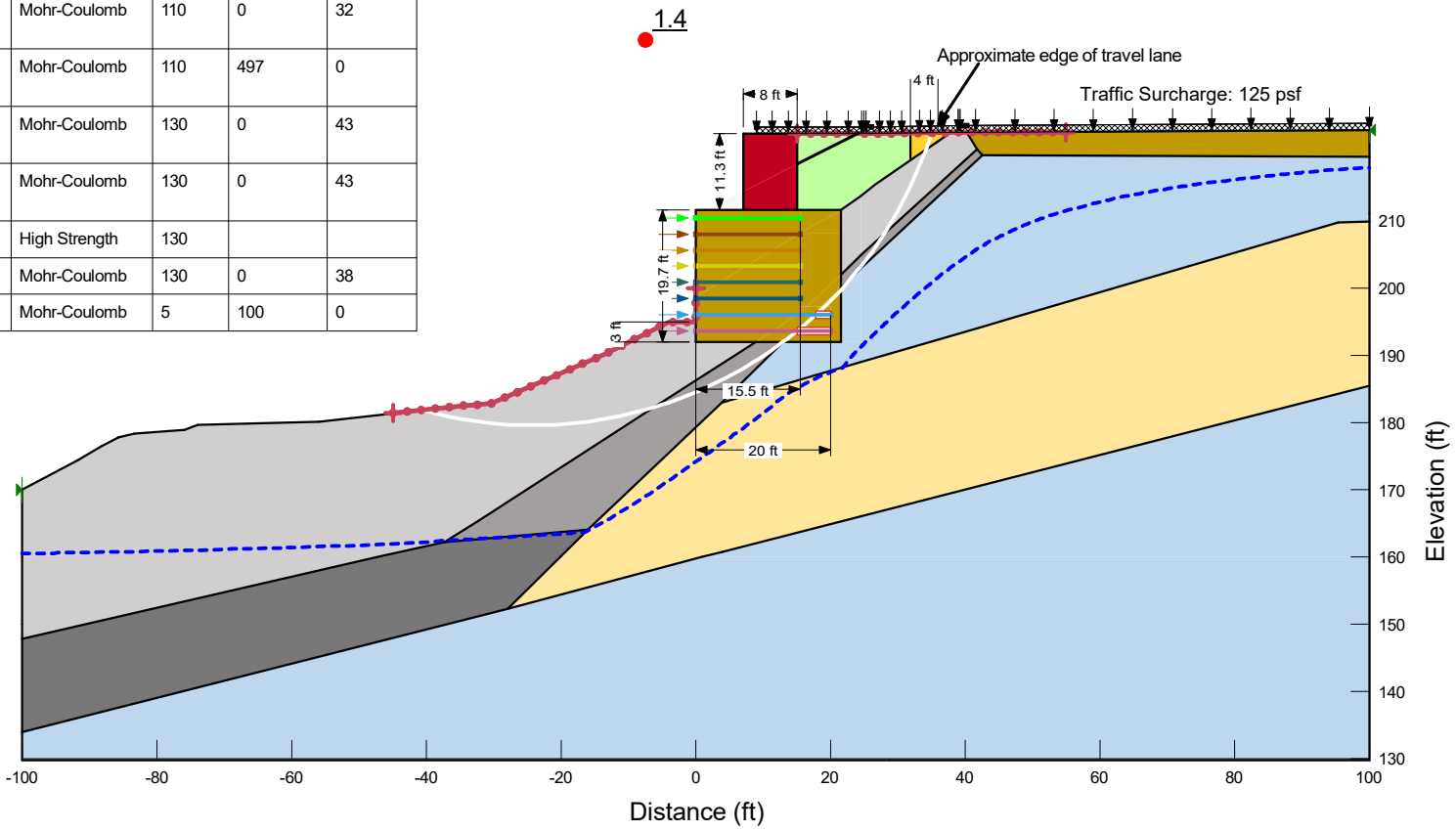
I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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Wall 05.85L-A - Sta. 1+90
Post-Seismic Compound Stability + FC Wall (S)

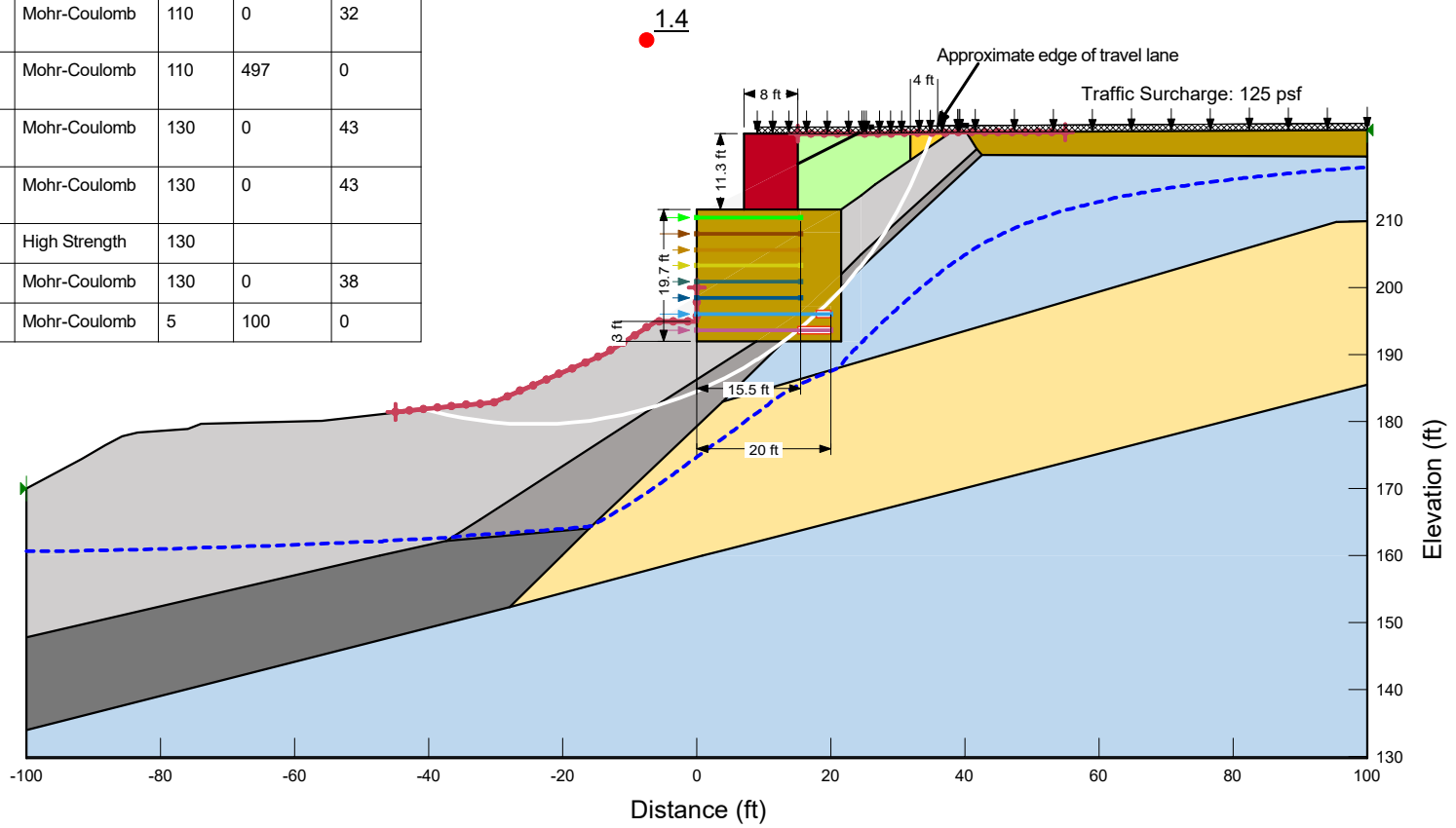
I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 12/21/21

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	Mohr-Coulomb	110	497	0
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1	6.6	3,930
	Row 2	6.1	3,930
	Row 3	5.6	3,930
	Row 4	5.1	3,930
	Row 5	4.6	3,930
	Row 6	4.1	3,930
	Row 7 (4 straps)	7.2	7,860
	Row 8 (4 straps)	6.2	7,860



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Wall 05.85L-A - Sta. 1+90
Post-Seismic Compound Stability + FC Wall (M-P)
I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 01/17/22

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Appendix F
Wall 05.85L-B Calculations

APPENDIX F - WALL 05.85L-B CALCULATIONS

General

This appendix presents geotechnical calculations for Wall 05.85L-B including:

- ESU Soil Properties
- Seismic Hazard Analysis
- Lateral Earth Pressures
- Coefficients of Friction for Sliding
- Bearing Resistance and Elastic Settlement
- Global Stability
- Compound Stability

ESU Soil Properties

Design soil properties were developed in accordance with the Project GDM, AASHTO LRFD, and FHWA. We calculated the average, geometric mean, and standard deviation within each ESU. We verified the reliability of the ESU data set by comparing the COV of each calculated geometric mean value to measured and interpreted values presented in Sabatini et al. (2002) Table 52.

A detailed description of the soil property development is presented in Section 7.1 of this geotechnical engineering report. Supporting calculations are provided in this appendix.

Seismic Hazard Analysis

We selected a representative site class for each wall from the site class evaluation of nearby borings. We evaluated the site class of each boring using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 3.10.3.1.

We developed seismic design parameters using the WSDOT Bridge Engineering Software BEToolbox/BridgeLink in accordance with the WSDOT BDM based on the projected ground motion at the project site that has a 7 percent (SEE) probability of exceedance in a 75-year period (approximate 1,000-year return period).

We used a mean earthquake magnitude at the PGA period is 6.97 for the SEE based on the Hart Crowser design report “I-405 R2B Segment 1a Site-Specific Hazard Analysis RFU,” dated March 25, 2021.

We evaluated the FS against liquefaction and liquefaction-induced settlement of saturated, loose to medium dense soils in accordance with the Project GDM Chapter 6 using a spreadsheet developed by GeoEngineers. The FSs against liquefaction at Wall 05.85L-B were greater than 1.2 for all soil analyzed; per Project GDM Section 6-4.2.3, soils with liquefaction potential are defined as those with FSs against liquefaction less than 1.2.

Detailed descriptions of our seismic hazard analysis methodology and the results are presented in Section 7.2 and Section 8.1, respectively, of this report. Site class calculations, WSDOT BDM software outputs, and liquefaction analyses are provided in this appendix.

Lateral Earth Pressures

Active static lateral pressure coefficients and corresponding lateral earth pressures for ESU 2B were calculated on the back of Wall 05.85L-B in accordance with AASHTO LRFD Section 3.11.5 using the proposed 2H:1V backslope behind the wall and 3.7H:1V foreslope in front of the wall. Static lateral earth pressures shall be applied using a triangular distribution. An LRFD load factor of 1.5 shall be applied to the static earth pressures in accordance with AASHTO LRFD Table 3.4.1-2.

Due to relatively shallow embedment of the wall combined with a foreslope condition, passive lateral earth pressures shall be ignored.

Active static + seismic lateral pressure coefficients and static + seismic lateral earth pressures were calculated using the GLE Method in accordance with AASHTO LRFD Section A11.3.3 and NCHRP Report 611 Section 7.4. The GLE analysis was

evaluated for Spencer's method using the computer design software Slope/W (Geo Slope International, Ltd. 2020). For the static + seismic earth pressures, we used a modified horizontal seismic coefficient, kh, coupling a 50 percent reduction for flexible wall displacements with a reduction for wave scattering effects. Static + seismic lateral earth pressures shall be applied using a triangular distribution. An LRFD load factor of 1.0 shall be applied to the static + seismic earth pressures in accordance with AASHTO LRFD Table 3.4.1-1.

Surcharge loads (such as traffic loading, fill loads above the wall, and forward compatible loading for future I-405 widening) and appropriate load factors shall also be applied to evaluate wall stability. All surcharges shall apply load factors in accordance with AASHTO LRFD Tables 3.4.1-1 and 3.4.1-2.

A detailed description of our analysis methodology and the calculated results are presented in Section 7.3 and Section 8.2, respectively. Supporting calculations are provided in this appendix.

Coefficients of Friction for Sliding

Coefficients of friction for sliding on surficial native soils, common borrow, select borrow, and gravel borrow were calculated using AASHTO LRFD equation 10.6.3.4-2.

A detailed description of our analysis methodology and the results are presented in Section 7.4 and Section 8.3, respectively, of this report. Supporting calculations are provided in this appendix.

Bearing Resistance and Elastic Settlement

We estimated the bearing resistance and elastic settlement of the wall using a spreadsheet developed by GeoEngineers in accordance with AASHTO LRFD Section 10.6.3. We estimated elastic settlement from procedures outlined in AASHTO LRFD and Section 10.6.2.4. Sliding, overturning, and internal stability are being evaluated by the design-build team's wall designers and will be submitted under separate cover.

A detailed description of our analysis methodology and the results are presented in Section 7.5 and Section 8.4, respectively, of this report. Supporting calculations are provided in this appendix.

Global Stability

We performed global stability analyses for the following critical design section:

- Section Sta. 2+60 – Maximum overall slope height

Global stability was evaluated using limit equilibrium analysis methodology outlined in the Project GDM using the computer design software Slope/W (Geo Slope International, Ltd. 2020). We analyzed FSs using Spencer's method and Morgenstern-Price for a circular failure surface.

We used an apparent cohesion in the surficial native soils for pseudo-static analyses. Apparent cohesion was based on the fines content ranges presented in Table 11-2 of the FHWA Geotechnical Engineering Circular No. 3. We used 50 psf apparent cohesion in the common borrow backfill behind the wall for the pseudo-static analyses; see the Compound Stability section below for a discussion on apparent cohesion in common borrow for this wall.

We modeled a 4-foot horizontal bench in front of the wall per AASHTO LRFD Section 11.10.2.2. We modeled a front face embedment depth of 3.5 feet based on the slope from the front of the horizontal bench to the existing ground surface using criteria outlined in AASHTO LRFD Table C11.10.2.2-1.

We used a minimum reinforcement length of 0.7H to model the SEW. We modeled a 1.5-foot clearance between the reinforced zone and the temporary shoring, which was backfilled with imported gravel borrow. See Section 8.8.3 in this geotechnical report for discussion on temporary shoring.

A uniform traffic surcharge of 250 psf was included in static stability analysis. A uniform traffic surcharge of 125 psf was included for the pseudo-static stability analyses. In accordance with Section 15.4.12 of the Project GDM, we used a load factor of 1.0 for the static traffic surcharge because it is a non-structural load.

The groundwater level was modeled using results from the seepage analysis at Wall 05.85L-A. Steady-state seepage results are presented in Appendix E.

We also evaluated the global stability of the wall with a forward compatible wall for future I-405 widening. We modeled the forward compatible wall directly above the proposed SEW with the face of the forward compatible wall set back 7 feet from the face of the SEW. We modeled the backfill behind the forward compatible wall as lightweight EPS using the strength properties presented in Table 7 and truncated the EPS behind the forward compatible wall at 4 feet from the proposed edge of the traveled way. The required minimum static and pseudo-static FSs were met for all forward compatible wall cases.

Detailed descriptions of our global stability analysis methodology and the results of our analyses are presented in Section 7.8 and Section 8.6, respectively, of this report. Global stability models showing FS for critical failures at the design section are provided in this appendix. Slope/W reports are provided in Appendix J.

Compound Stability

We used the results of the global stability analyses to model and evaluate compound stability at the critical design section using the minimum reinforcement lengths required to meet the minimum FSs from the global stability analyses. We modeled 10 rows of reinforcing strips at a length of 0.7H (2 strips per row per panel).

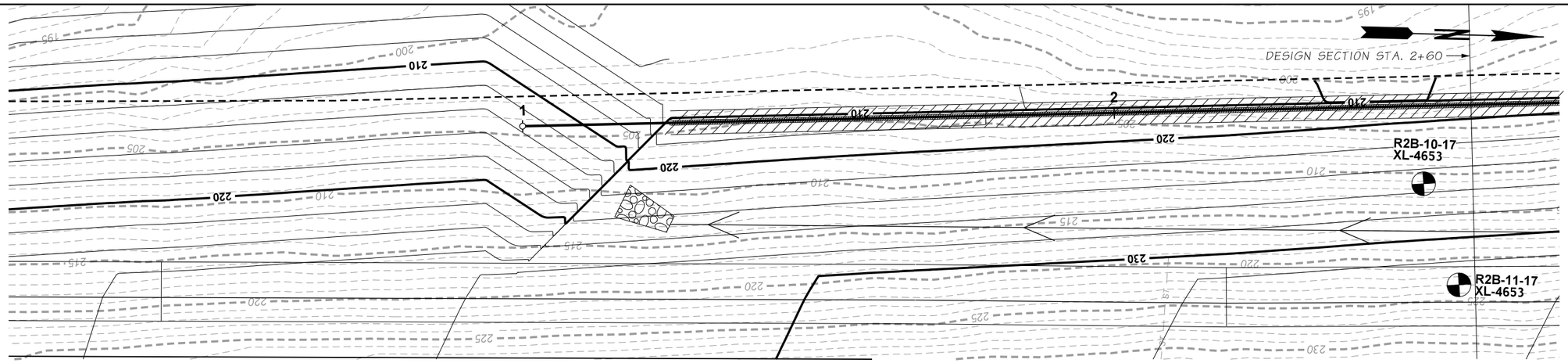
We used the horizontal seismic coefficient, kh, for compound stability presented in Table 8 and applied the apparent cohesion for native soils presented in Table 6 for the pseudo-static analysis. To meet minimum FSs for Wall 05.85L-B, we applied 50 psf apparent cohesion to the common borrow backfill. To meet the fines content required to use an apparent cohesion of 50 psf, as specified in FHWA Geotechnical Engineering Circular No. 3 Table 11-2, common borrow backfill shall be Option 2 per WSDOT Standard Specification 9-03.14(3).

We applied a uniform traffic surcharge of 437.5 psf directly over the reinforced zone and a uniform traffic surcharge of 250 psf outside of the reinforced zone for the static compound stability analysis, and a traffic surcharge of 125psf for the pseudo-static compound stability analysis.

We used the piezometric surface from the seepage analysis at Wall 05.85L-A to model the groundwater level. Steady-state seepage results are presented in Appendix E.

We also evaluated the compound stability of proposed Wall 05.85L-B considering forward compatible walls for future I-405 widening, using the same geometry and strength properties from the global stability analyses for the forward compatible wall. As one option to meet required compound stability minimum FSs, we modeled the backfill as lightweight EPS. We did not explore all potential options as design of the forward compatible walls is outside the scope of this project, but minimally, the option we did analyze demonstrated that future I-405 widening projects can be designed and constructed without demolition or reconstruction of Wall 05.85L-B.Detailed descriptions of our compound stability analysis methodology and the results of our analyses are presented in Section 7.9 and Section 8.7, respectively, of this geotechnical report. Compound stability models showing FS for critical failures at the design section are provided in this appendix. Slope/W reports are provided in Appendix K.

Appendix F.1 - Wall 05.85L-B
Plan, Profile and Sections



PLAN - WALL 05.85L-B

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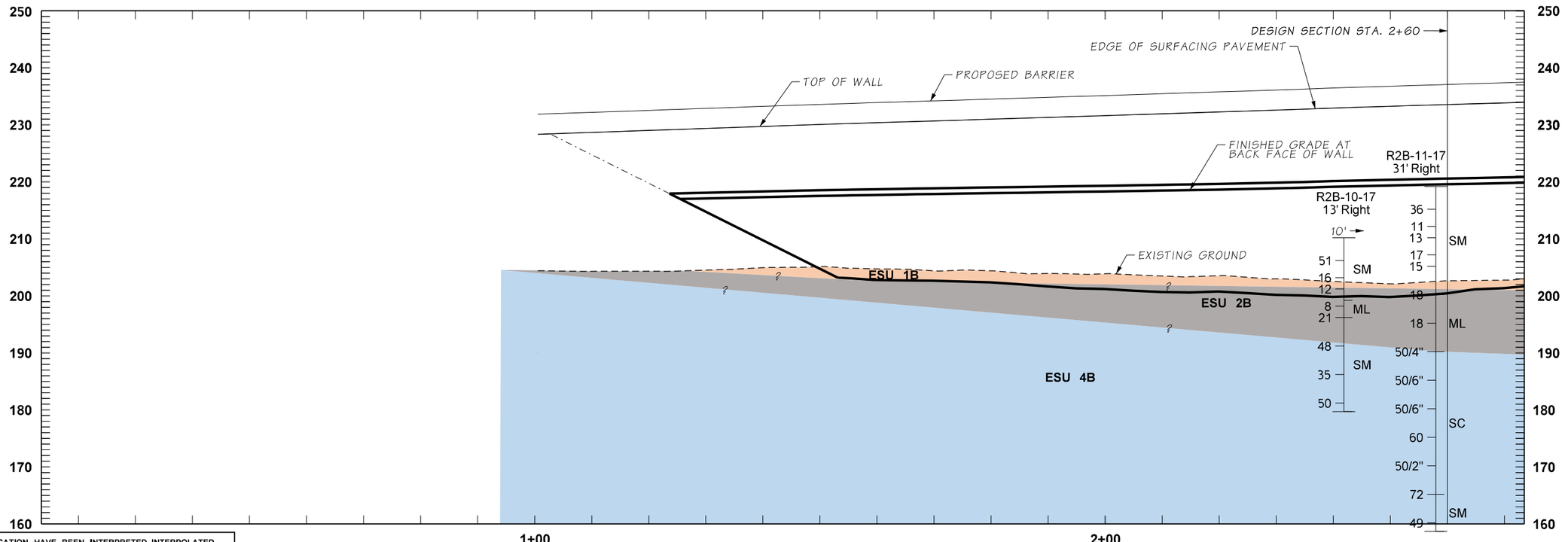
SCALE IN FEET



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS, SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

REFLECTIVE ELEVATION - WALL 05.85L-B

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CHECKED BY							
PROJ. ENGR.							
REGIONAL ADM.		REVISION	DATE	BY			

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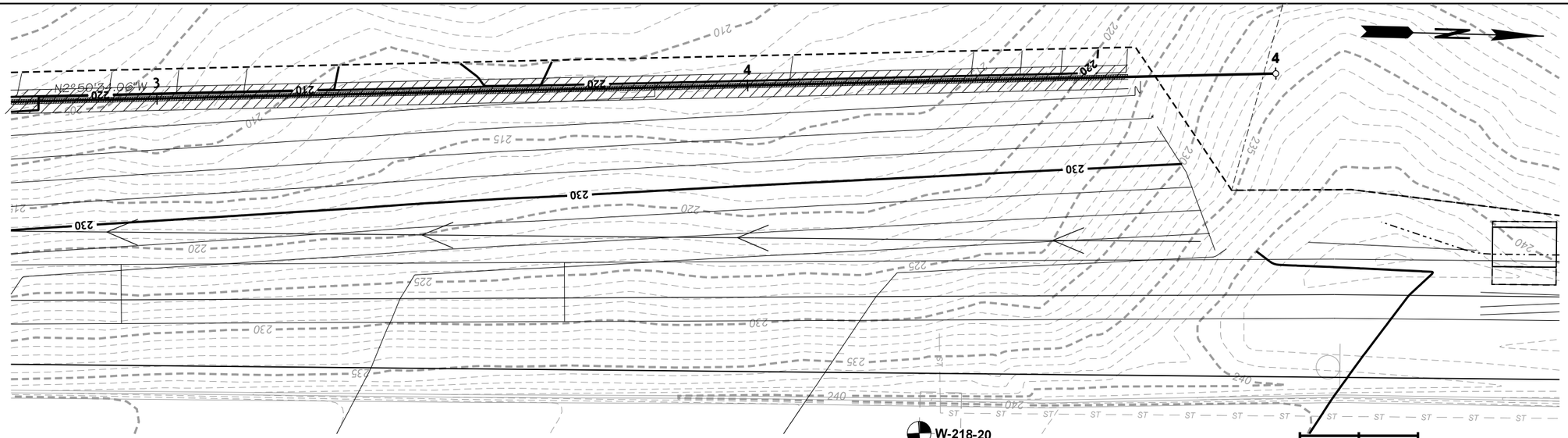
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

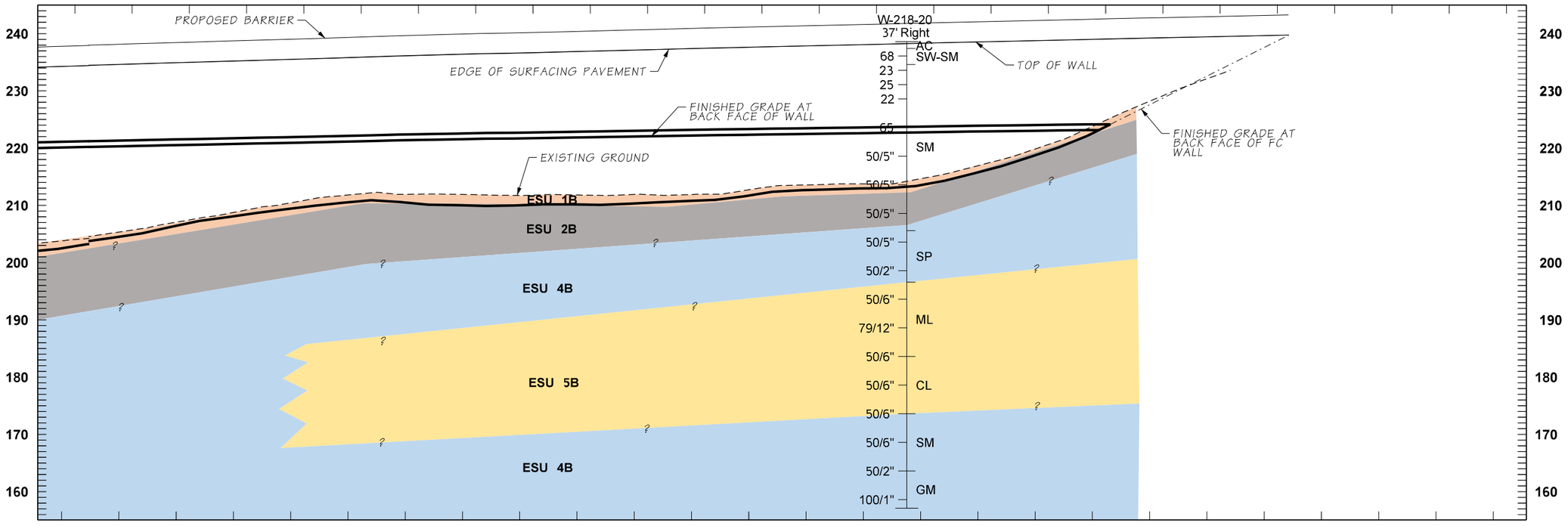
RETAINING WALL PLAN AND ELEVATION
WALL 05.85L-B

PLAN REF NO

SHEET 1 OF 2 SHEETS



PLAN - WALL 05.85L-B



THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS, SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

REFLECTIVE ELEVATION - WALL 05.85L-B

DATUM (NAVD) 88

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10	WASH	
JOB NUMBER		
CONTRACT NO.		LOCATION NO.

P.E. STAMP BOX — DATE

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Washington State Department of Transportation

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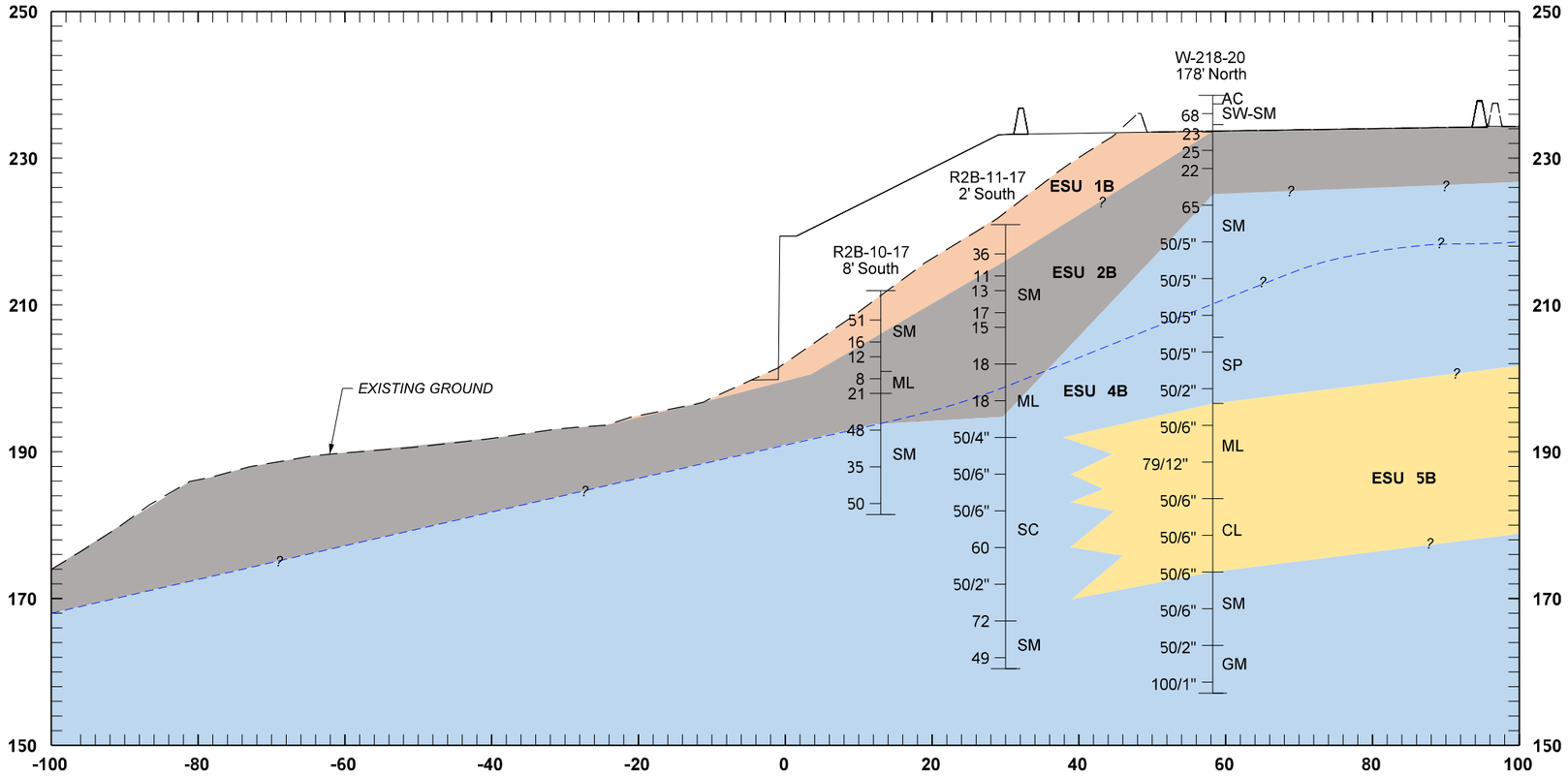
I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

RETAINING WALL PLAN AND ELEVATION WALL 05.85L-B

PLAN REF NO

SHEET 2 OF 2 SHEETS



WALL 05.85L-B STATION 2+60

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

WALL 05.85L-B
DESIGN SECTION AT STA. 2+60

PLAN REF NO

SHEET 1 OF 1 SHEETS

Appendix F.2 - Wall 05.85L-B ESU Soil Property Calculations

ESU	Description	Total No. of Samples [b]	USCS [c]	Fines [d] (%)	Plasticity Index, PI [e] (%)	Raw N (bpf)	N_{60} [f] (bpf)		$(N_1)_{60}$ [f] (bpf)		Total Unit Weight [g] (pcf)		Effective Friction Angle, ϕ' [h] (deg)		Fully Softened ϕ' [i] (deg)	Effective c' [j] (psf)	Residual ϕ' [k] (deg)	Residual Shear Strength, Sr (psf)	Undrained Shear Strength, Su (psf)	
				Value	Value	Value	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	COV [a]	Value	Value	Value	Value	Value	COV
1B	Medium Dense to Very Dense Coarse-Grained Fill	3	SM	21	-	50	51	20%	77	24%	130	0%	41	3%	-	-	-	-	-	-
2B	Medium Dense Sand/Gravel	13	SM	38	3	16	19	25%	23	22%	115	3%	34	3%	-	-	-	-	-	-
4B	Dense to Very Dense Sand/Gravel	20	SM	19	5	113	103	27%	89	27%	130	1%	43	3%	-	-	-	-	-	-
5B	Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	4	CL/ML	96	10	94	108	11%	86	11%	130	0%	42	1%	-	-	-	-	-	-

Notes:

a. Coefficient of Variation (COV) percentage calculated to verify the variability and reliability of sample data within ESU (WSDOT GDM Section 5.11.2 (2015)). Calculated COV percentage compared to ranges presented in Table 52 (Sabatini et al. 2002) (below).

b. Number of samples excludes outliers.

c. Predominant USCS classification of all samples in ESU. Sandstone, where encountered, denoted as (SS).

d. Fines content percentage calculated as the geometric mean of all samples, whose values were determined through lab testing or estimated from field classification.

e. For coarse-grained ESUs, the plasticity index was estimated on the fine-grained portion of the soil. For fine-grained ESUs, if lab data is limited, the plasticity index may not be representative of the overall soil unit.

f. Corrected blow counts (N_{60} and $(N_1)_{60}$) were calculated following WSDOT GDM Section 5.5 (2015).

g. Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Unit weight data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.

h. Design friction angles were selected by considering fines content. Friction angle data variability and quality were evaluated by comparing the calculated COV percentage to the applicable Sabatini range.

i. Where applicable, fully softened friction angle was estimated following WSDOT GDM, Figure 5-7 (After Stark and Hussain, 2013).

j. Where applicable, effective cohesion was calculated using Equations 6 through 8 in the WOOD Geotechnical SPM.

k. Where applicable, residual friction angle (to be used for slope stability evaluation) was estimated following WSDOT GDM, Figure 5-5 (After NAVFAC, 1971).

Measured or interpreted parameter value	Coefficient of Variation, V (%)
Unit weight, γ	3 to 7 %
Buoyant unit weight, γ_b	0 to 10 %
Effective stress friction angle, ϕ'	2 to 13 %
Undrained shear strength, s_u	13 to 40 %
Undrained strength ratio (s_u/σ_v')	5 to 15 %
Compression index, C_c	10 to 37 %
Preconsolidation stress, σ_p'	10 to 35 %
Hydraulic conductivity of saturated clay, k	68 to 90 %
Hydraulic conductivity of partly-saturated clay, k	130 to 240 %
Coefficient of consolidation, c_v	33 to 68 %
Standard penetration blowcount, N	15 to 45 %
Electric cone penetration test, q_c	5 to 15 %
Mechanical cone penetration test, q_c	15 to 37 %
Vane shear test undrained strength, s_{uVST}	10 to 20 %

Source: Table 52 (Sabatini et al. 2002)

	ESU Name:	ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill									
		N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	50	51	77	21	-	44	39	130	-	-
	Average:	52	52	79	24	-	44	39	130	-	-
	St. Dev.:	16.0	10.3	19.2	-	-	1.1	1.1	0.0	-	-
	COV:	0.31	0.20	0.24	-	-	0.02	0.03	0.00	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-218-20	236.1	68	59	97	9	-	45	40	#N/A	-	-	SW-SM	
R2B-11-17	215.2	36	40	59	29	-	43	38	130	-	-	SM	
R2B-10-17	206.2	51	56	82	35	-	45	40	130	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill

1. Check N160 COV is between 15 and 45%

Selected Design N160:	77
Coefficient of Variation (COV):	0.24

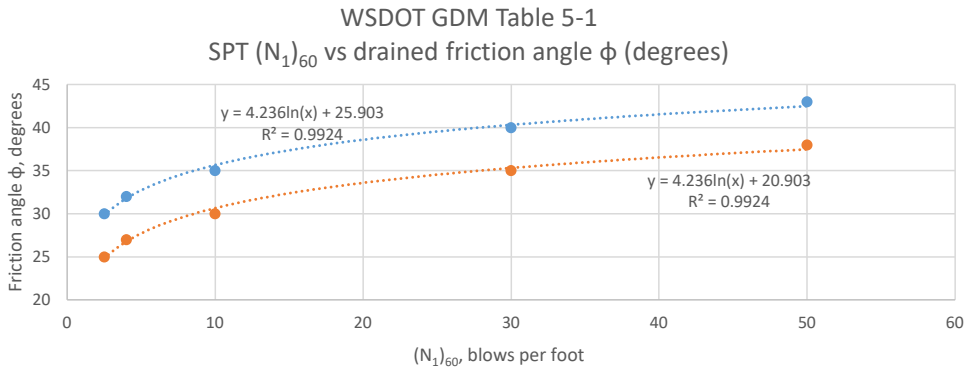
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	44	39	42

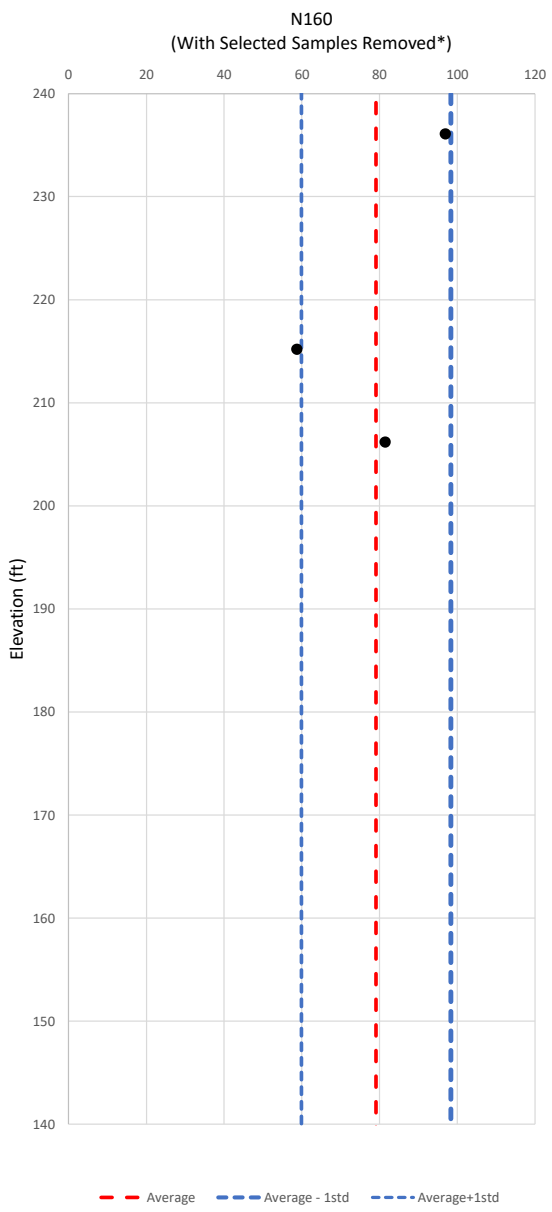
ϕ' COV
0.03

Selected Design Phi' (deg):	41
Notes on Selection:	The estimated fines content is 21% (geomean). The friction angle is interpolated based on fines content (phi' (high) at 5% fines, and phi' (low) at 30% fines).

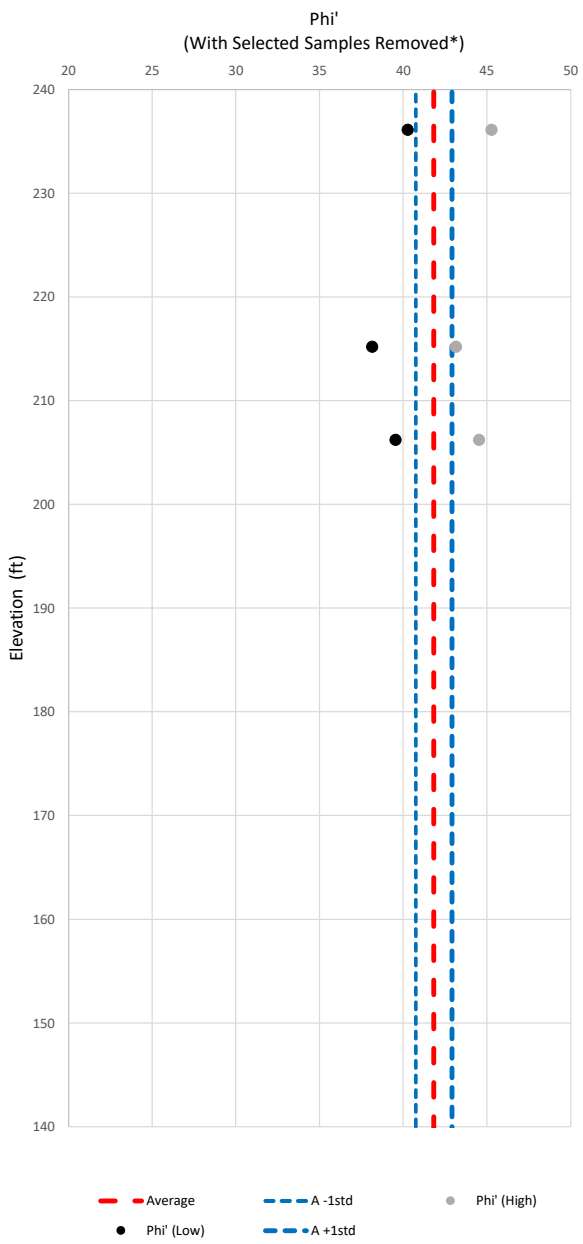
Pick Representative USCS:	SM
Pick Representative Unit Weight:	130
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 0%.

*Using Predominant USCS Classification

ESU 1B - Medium Dense to Very Dense Coarse-Grained Fill



*See sample table for explanation for removing specified samples if applicable



ESU Name:	ESU 2B - Medium Dense Sand/Gravel									
	N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
GeoMean:	16	19	23	38	3	39	34	115	-	-
Average:	17	20	24	43	3	39	34	115	-	-
St. Dev.:	5.0	5.0	5.2	-	-	1.1	1.1	3.8	-	-
COV:	0.30	0.25	0.22	-	-	0.03	0.03	0.03	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-218-20	233.6	23	21	32	33	-	41	36	120	-	-	SM	
W-218-20	231.1	25	23	30	33	-	40	35	120	-	-	SM	
W-218-20	228.6	22	22	26	33	-	40	35	120	-	-	SM	
R2B-11-17	212.2	11	13	19	29	-	38	33	115	-	-	SM	
R2B-11-17	210.2	13	16	22	29	-	39	34	115	-	-	SM	
R2B-11-17	207.2	17	21	25	29	-	40	35	120	-	-	SM	
R2B-11-17	205.2	15	19	21	29	-	39	34	115	-	-	SM	
R2B-11-17	200.2	18	25	25	97	-	40	35	110	-	-	ML	
R2B-11-17	195.2	18	25	24	97	3	39	34	115	-	-	ML	
R2B-10-17	203.2	16	19	26	35	-	40	35	120	-	-	SM	
R2B-10-17	201.2	12	15	20	35	-	39	34	115	-	-	SM	
R2B-10-17	198.2	8	10	12	70	-	36	31	110	-	-	ML	
R2B-10-17	196.2	21	26	29	15	-	40	35	120	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 2B - Medium Dense Sand/Gravel

1. Check N160 COV is between 15 and 45%

Selected Design N160:	23
Coefficient of Variation (COV):	0.22

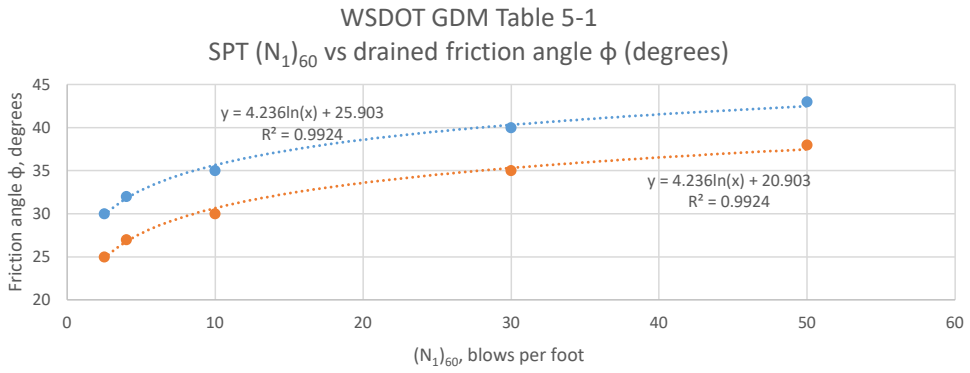
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	39	34	37

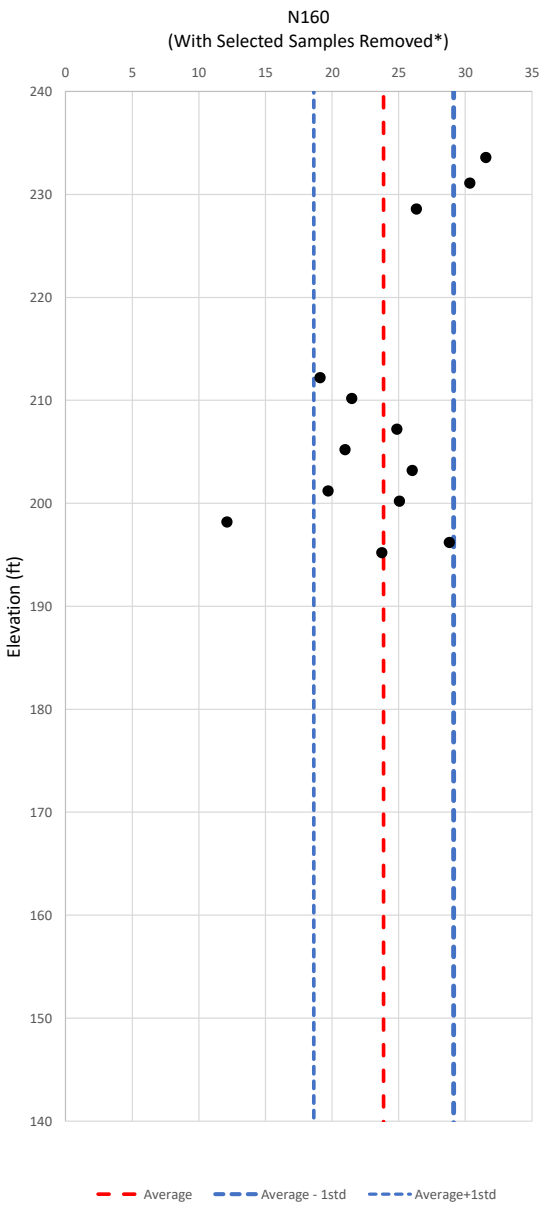
ϕ' COV
0.03

Selected Design Phi' (deg):	34
Notes on Selection:	The estimated fines content is 38% (geomean). The high fines content supports the use of the lower bound of the friction angle range.

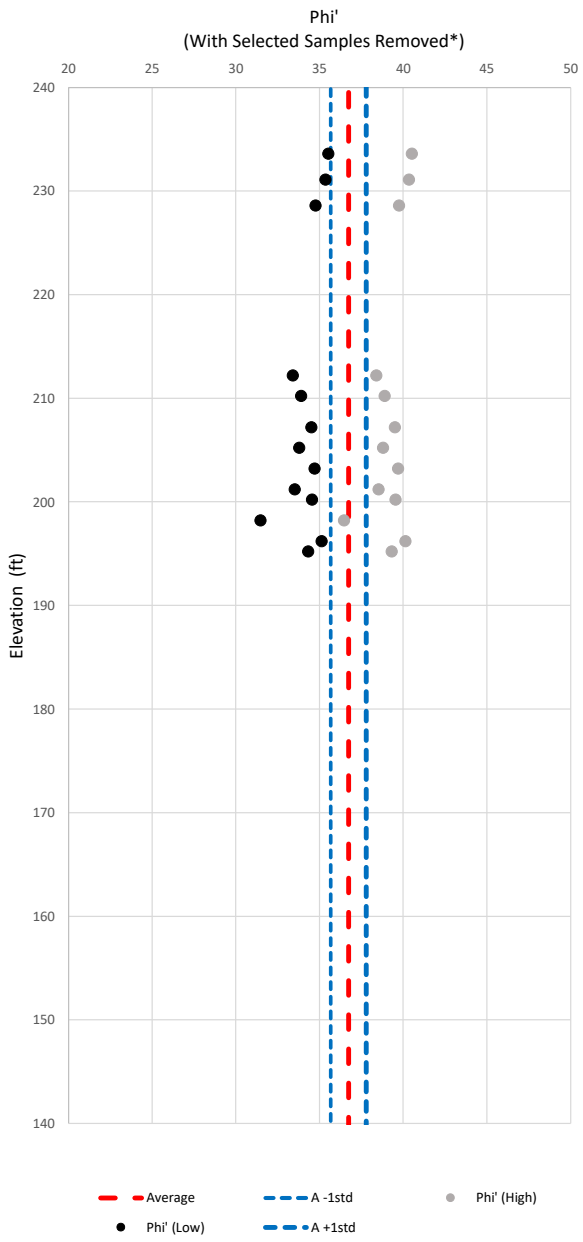
Pick Representative USCS:	SM
Pick Representative Unit Weight:	115
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 3%.

*Using Predominant USCS Classification

ESU 2B - Medium Dense Sand/Gravel



*See sample table for explanation for removing specified samples if applicable



	ESU Name:	ESU 4B - Dense to Very Dense Sand/Gravel									
		N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
	GeoMean:	113	103	89	19	5	45	40	130	-	-
	Average:	175	107	92	22	6	45	40	130	-	-
	St. Dev.:	255.0	28.9	24.5	-	-	1.2	1.2	1.5	-	-
	COV:	1.45	0.27	0.27	-	-	0.03	0.03	0.01	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-218-20	223.6	65	71	74	41	-	44	39	130	-	-	SM	
W-218-20	218.6	120	109	105	45	3	46	41	130	-	-	SM	
W-218-20	213.6	120	109	99	36	-	45	40	130	-	-	SM	
W-218-20	208.6	120	115	99	36	-	45	40	130	-	-	SM	
W-218-20	203.6	120	115	97	5	-	45	40	135	-	-	SP	
W-218-20	198.6	300	115	95	5	-	45	40	135	-	-	SP	
W-218-20	173.6	100	115	87	15	-	45	40	130	-	-	SM	
W-218-20	168.6	100	115	86	15	-	45	40	130	-	-	SM	
W-218-20	163.6	300	115	85	25	-	45	40	130	-	-	GM	
W-218-20	158.6	1200	115	84	25	-	45	40	130	-	-	GM	
R2B-11-17	190.2	150	147	137	22	-	47	42	130	-	-	SC	
R2B-11-17	185.2	100	147	133	22	9	47	42	130	-	-	SC	
R2B-11-17	180.2	100	147	129	22	-	46	41	130	-	-	SC	
R2B-11-17	175.2	60	88	76	22	-	44	39	130	-	-	SC	
R2B-11-17	170.2	300	147	123	22	-	46	41	130	-	-	SC	
R2B-11-17	165.2	72	106	87	18	-	45	40	130	-	-	SM	
R2B-11-17	160.2	49	72	58	18	-	43	38	130	-	-	SM	
R2B-10-17	191.2	48	67	67	15	-	44	39	130	-	-	SM	
R2B-10-17	186.2	35	49	47	15	-	42	37	130	-	-	SM	
R2B-10-17	181.2	50	74	69	15	-	44	39	130	-	-	SM	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 4B - Dense to Very Dense Sand/Gravel

1. Check N160 COV is between 15 and 45%

Selected Design N160:	89
Coefficient of Variation (COV):	0.27

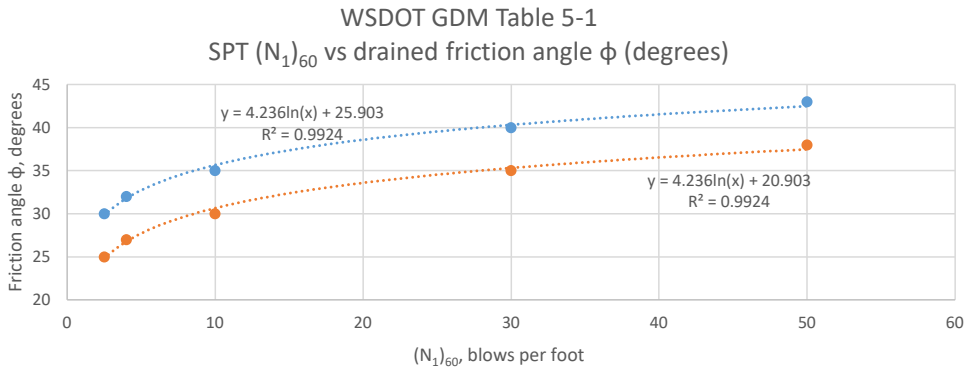
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	45	40	42

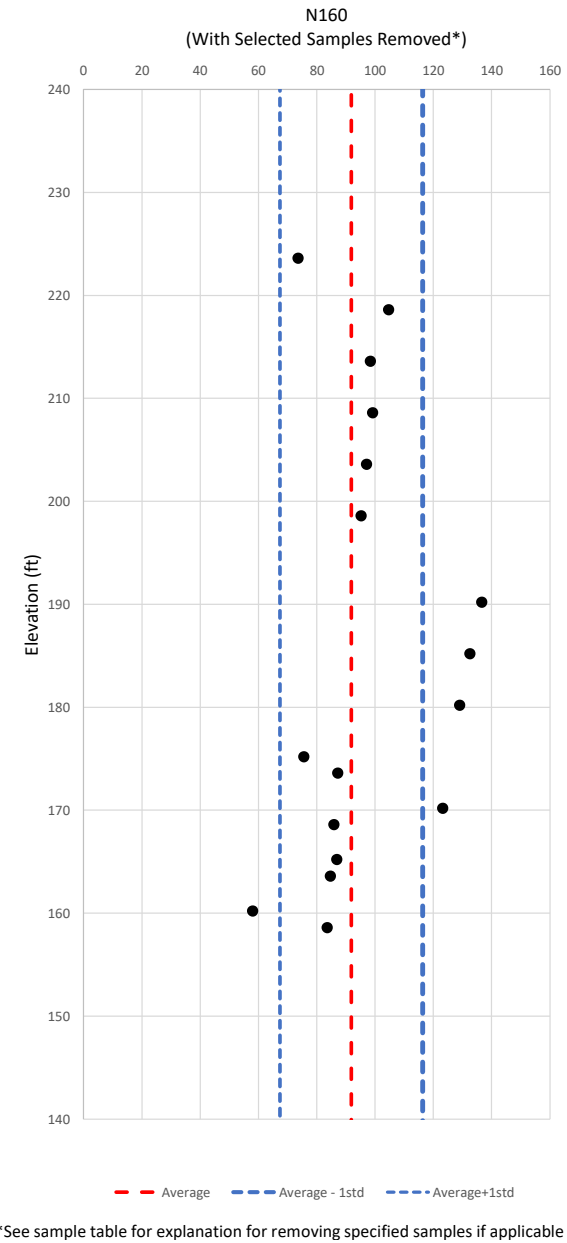
ϕ' COV
0.03

Selected Design Phi' (deg):	43
Notes on Selection:	The estimated geomean fines content is 19% (geomean). The friction angle is taken as the upper bound and capped at 43 degrees for glacially consolidated material with fines content less than 70%.

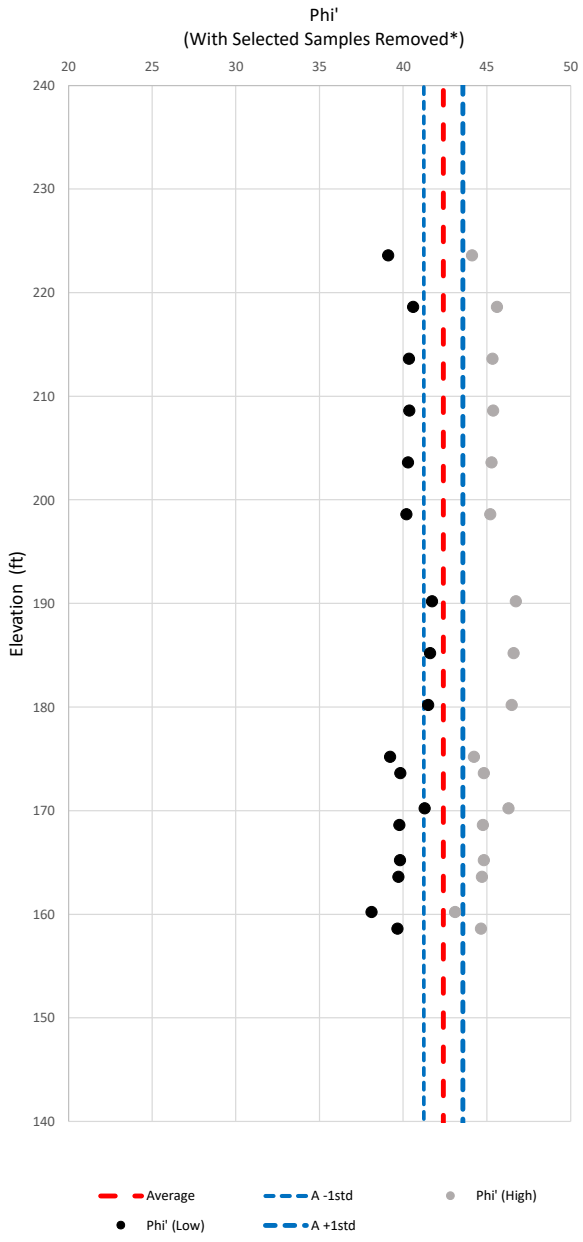
Pick Representative USCS:	SM
Pick Representative Unit Weight:	130
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 1%.

*Using Predominant USCS Classification

ESU 4B - Dense to Very Dense Sand/Gravel



*See sample table for explanation for removing specified samples if applicable



ESU Name:	ESU 5B - Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt									
	N	N_{60}	$(N_1)_{60}$	%F	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr (psf)
GeoMean:	94	108	86	96	10	45	40	130	-	-
Average:	95	109	86	97	11	45	40	130	-	-
St. Dev.:	10.5	12.1	9.4	-	-	0.5	0.5	0.0	-	-
COV:	0.11	0.11	0.11	-	-	0.01	0.01	0.00	-	-

Boring	Elevation	N	N_{60}	$(N_1)_{60}$	%F [3]	PI (Lab)	ϕ' (high) (deg)	ϕ' (low) (deg)	Sat. Unit Weight	Su (psf)	Sr [4] (psf)	USCS	Explanation for Sample Removal
W-218-20	193.6	100	115	93	98	8	45	40	130	-	-	ML	
W-218-20	188.6	79	91	72	98	-	44	39	130	-	-	ML	
W-218-20	183.6	100	115	90	95	13	45	40	130	-	-	CL	
W-218-20	178.6	100	115	89	95	-	45	40	130	-	-	CL	

Notes:

1. Highlighted cells in yellow if shown represent samples that were removed as outliers.
2. Friction angle, unit weight, and corrected blow count values were correlated using specified methodology in the WOOD Geotechnical SPM. Where applicable, undrained Shear Strength of fine grained ESUs were determined using Equation 9 in the WOOD Geotechnical SPM.
3. Fines content percentages determined through laboratory testing are highlighted in orange if shown. Non-highlighted values have been estimated from sample field classifications, applying the fines content of a lab tested sample with similar properties, or using the average of two lab tested samples.
4. Where applicable, residual strength is calculated using the existing relationships and weighting scheme per the GDM (section 6-2.2) to determine residual strengths for samples with (N1)60cs less than or equal to 20. Per Kramer 2008, samples that triggered liquefaction (FoS<1.2) but also has an (N1)60cs>20, uses the residual strength value for a soil with (N1)60cs=20, effectively capping the residual strength calculation at (N1)60cs=20.

ESU 5B - Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

1. Check N160 COV is between 15 and 45%

Selected Design N160:	86
Coefficient of Variation (COV):	0.11

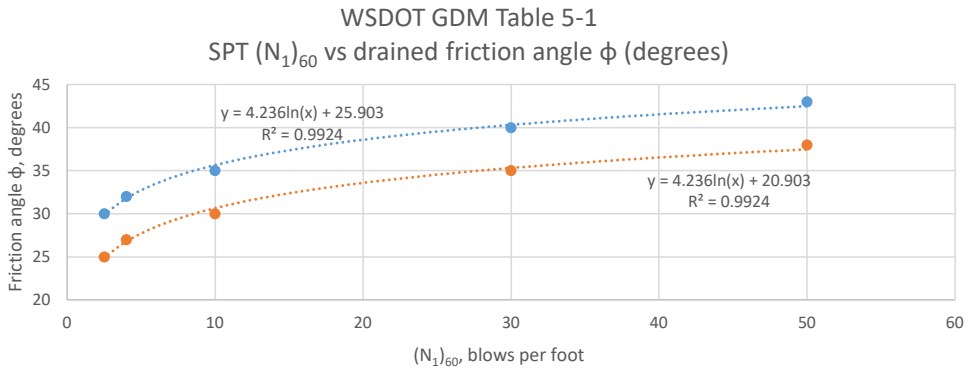
* 15 and 45% come from GEC 5 Sabatini (2002)

2. Check Phi' is between 2 to 13%

$(N_1)_{60}$ (blows per foot)	Friction angle ϕ (degrees)
2.5	25
2.5	30
4	27
4	32
10	30
10	35
30	35
30	40
50	38
50	43

* Phi' Developed from WSDOT Correlation

* 2 to 13% comes from GEC 5 Sabatini (2002)



	ϕ (high)	ϕ (low)	ϕ (avg)
GeoMean:	45	40	42

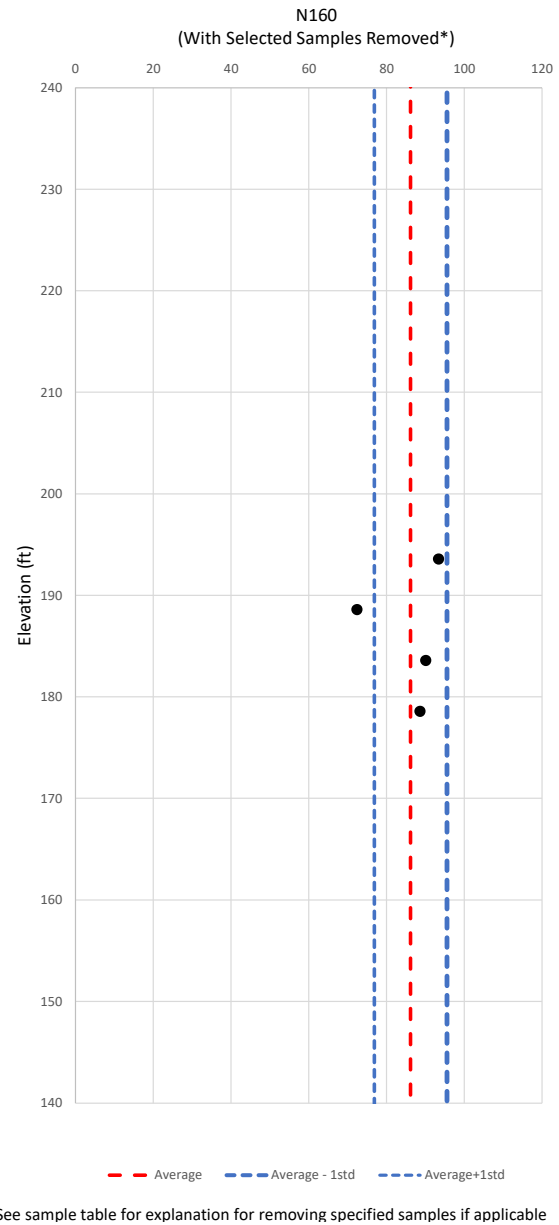
ϕ' COV
0.01

Selected Design Phi' (deg):	42
Notes on Selection:	The estimated geomean fines content is 96% (geomean). The friction angle is taken as the average of upper bound and lower bound and capped at 43 degrees for glacially consolidated material with fines content more than 70%.

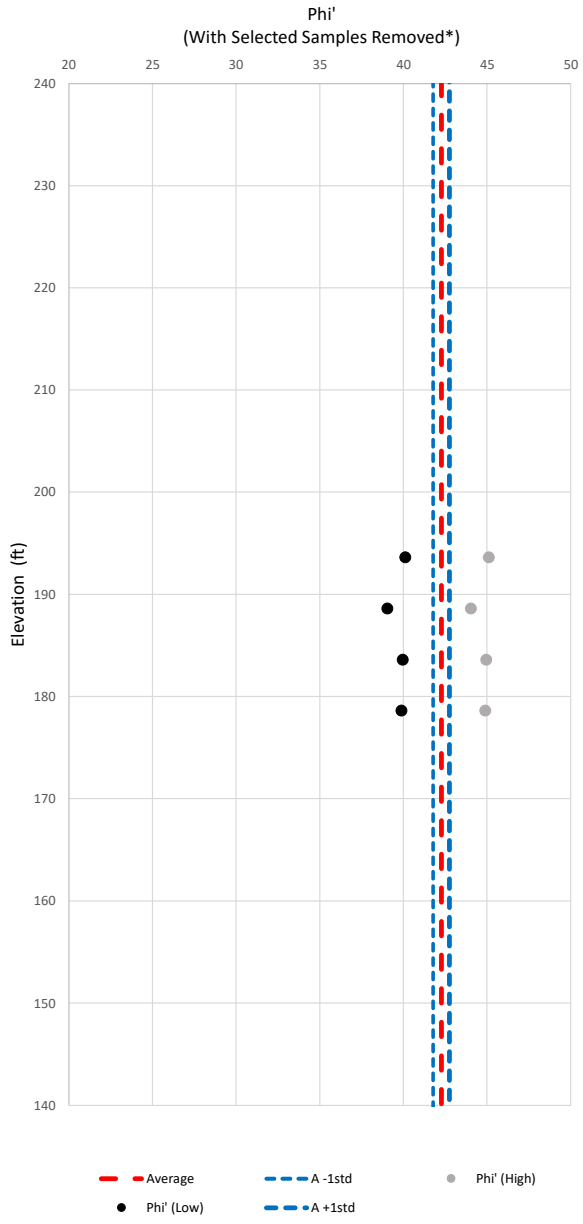
Pick Representative USCS:	CL/ML
Pick Representative Unit Weight:	130
Notes on Selection:	Individual sample unit weights were correlated using CALTRANS Geotechnical Manual (2014), verified with applicable ranges presented in Codotu (2001), as specified in WOOD SPM. The geometric mean of the unit weights was rounded to the nearest 5pcf, as specified in WOOD SPM. Data set COV was 0%.

*Using Predominant USCS Classification

ESU 5B - Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt



*See sample table for explanation for removing specified samples if applicable



One of the primary shortcomings of the Mononobe-Okabe method is that it cannot consider the effect of cohesion in the backfill on the seismic active earth pressure. Even relatively small amounts of cohesion in the backfill can significantly reduce the seismic active earth pressure. Sources of cohesion in backfill soils include both true cohesion due to inter-particle bonding and apparent cohesion due to capillary forces in the backfill. The influence of cohesion on the seismic active earth pressure is a function of the normalizing parameter $c\gamma/H$, where γ is the unit weight of the backfill soil. Figure 11-14 presents a plot of the seismic active earth pressure coefficient, k_{AE}, as a function of the normalizing parameter $c/\gamma H$ and the seismic coefficient, k_h, for a friction angle of 35° and for a uniform level backfill. An Appendix in NCHRP Report 611 presents additional plots for friction angles of 30° and 40°.

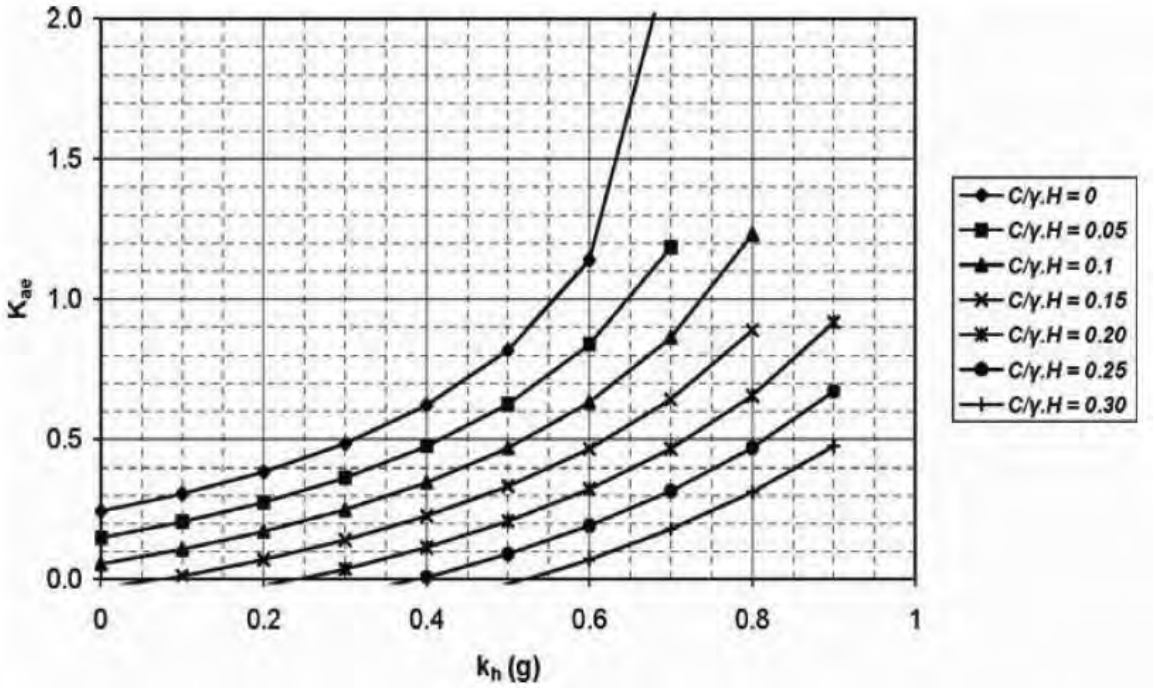


Figure 11-14 Effect of cohesion on the seismic active earth pressure coefficient for $\phi = 35°$ (NCHRP, 2008)

NCHRP Report 611 provides recommendations for the maximum amount of apparent cohesion that should be assumed for backfill soil as a function of the fines content of the soil. These recommendations are presented in Table 11-2.

TABLE 11-2 MAXIMUM AMOUNT OF APPARENT COHESION THAT SHOULD BE ASSUMED FOR BACKFILL SOILS (NCHRP, 2008)

% (by weight) passing #200 sieve	maximum apparent cohesion

5 - 15	50 psf
15 - 25	100 psf
25-50	200 psf

ESU 1B (FC=20%)

ESU 2B (FC=39%)

11.3.3 Log Spiral Earth Pressure Theory

The Mononobe-Okabe and Trial Wedge methods for calculating earth pressure assume that the failure surface in the backfill is planar. It has been long recognized that when there is a significant soil-wall friction angle, the assumption of the planar failure surface is incorrect. Instead, in a homogeneous soil a logarithmic surface gives the critical values for the active and passive earth pressure in a limit equilibrium analysis. Note, however, that when there is no wall friction the logarithmic surface degenerates to a planar surface. As illustrated in Figure 11-15, or the active case the difference between the critical log spiral surface and the critical planar surface is small enough that it can be ignored, even when there is wall friction. However, as illustrated in Figure 11-15, the critical log spiral surface for the passive case differs significantly from the critical planar surface when the wall friction angle is more than one-third the value of the backfill friction angle. In these cases it is essential to consider the logarithmic surface: failure to do so can result in an unconservative assessment of the seismic passive earth pressure.

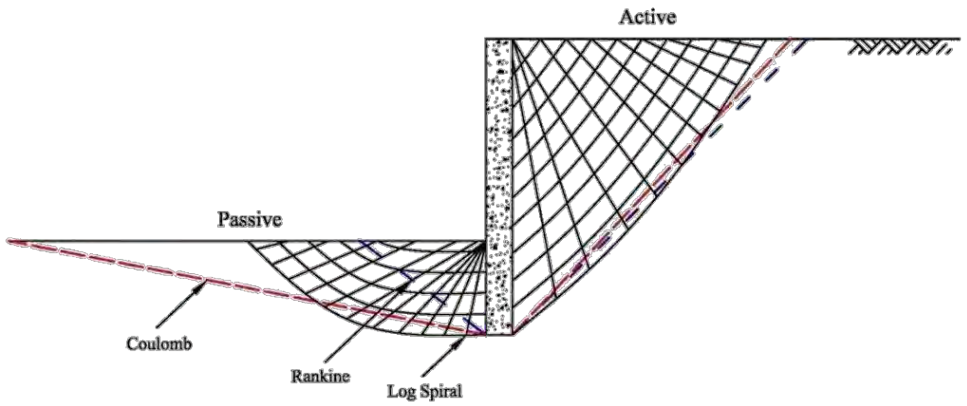


Figure 11-15 Critical Log Spiral Surfaces Compared to Planar Critical Surfaces

The log spiral method can be used to evaluate seismic passive earth pressures accounting for backfill friction and cohesion, soil-wall interface friction angle, and backslope angle. Shamsabadi et al. (2007) describe the general method that can be used to do this. The soil-wall interface friction angle is a key parameter in this approach. The soil-wall interface friction angle for static loading is often assumed to

A profile of σ_p', or OCR = σ_p'/σ_o', with depth should be developed for the site for design applications where the stress history could have a significant impact on the design properties selected and the performance of the foundation. As with consolidation properties, an upper and lower bound profile should be developed based on laboratory tests and plotted with a profile based on particular in-situ test(s), if used. It is particularly important to accurately compute preconsolidation stress values for relatively shallow depths where in-situ effective stresses are low. An underestimation of the preconsolidation stress at shallow depths will result in overly conservative estimates of settlement for shallow soil layers.

The coefficient of consolidation, c_v, should be determined from the results of one-dimensional consolidation tests. The variability in laboratory determination of c_v results should be considered in the final selection of the value of c_v to be used for design.

Due to the numerous simplifying assumptions associated with conventional consolidation theory, on which the coefficient of consolidation is based, it is unlikely that even the best estimates of c_v from high-quality laboratory tests will result in predictions of time rate of settlement in the field that are significantly better than a prediction within one order of magnitude. In general, the in-situ value of c_v is larger than the value measured in the laboratory test. Therefore, a rational approach is to select average, upper, and lower bound values for the appropriate stress range of concern for the design application. These values should be compared to values obtained from previous work performed in the same soil deposit. Under the best-case conditions, these values should be compared to values computed from measurements of excess pore pressures or settlement rates during construction of other structures.

CPTu tests in which the pore pressure dissipation rate is measured may be used to estimate the field coefficient of consolidation.

For preliminary analyses or where accurate prediction of settlement is not critical, values obtained from correlations to index properties presented in Sabatini et al. (2002) may be used.

Where evaluation of elastic settlement is critical to the design of the foundation or selection of the foundation type, in-situ methods such as PMT or *DMT* for evaluating the modulus of the stratum should be used.

For preliminary design or for final design where the prediction of deformation is not critical to structure performance, i.e., the structure design can tolerate the potential inaccuracies inherent in the correlations. The elastic properties (E_s, ν) of a soil may be estimated from empirical relationships presented in Table C10.4.6.3-1.

The specific definition of E_s is not always consistent for the various correlations and methods of in-situ measurement. See Sabatini et al. (2002) for additional details regarding the definition and determination of E_s.

An alternative method of evaluating the equivalent elastic modulus using measured shear wave velocities is presented in Sabatini et al. (2002).

Table C10.4.6.3-1—Elastic Constants of Various Soils (modified after U.S. Department of the Navy, 1982; Bowles, 1988)

Soil Type	Typical Range of Young's Modulus Values, E_s (ksi)	Poisson's Ratio, ν (dim)
Clay:		
Soft sensitive		
Medium stiff to stiff	0.347–2.08	0.4–0.5 (undrained)
	2.08–6.94	
Very stiff	6.94–13.89	
Loess	2.08–8.33	0.1–0.3
Silt	0.278–2.78	0.3–0.35
Fine Sand:		
Loose	1.11–1.67	0.25
Medium dense	1.67–2.78	
Dense	2.78–4.17	
Sand:		
Loose	1.39–4.17	0.20–0.36
Medium dense	4.17–6.94	
Dense	6.94–11.11	0.30–0.40
Gravel:		
Loose	4.17–11.11	0.20–0.35
Medium dense	11.11–13.89	
Dense	13.89–27.78	0.30–0.40
Estimating E_s from *SPT N* Value		
Soil Type		E_s (ksi)
Silts, sandy silts, slightly cohesive mixtures		0.056 $N_{1,60}$
Clean fine to medium sands and slightly silty sands		0.097 $N_{1,60}$
Coarse sands and sands with little gravel		0.139 $N_{1,60}$
Sandy gravel and gravels		0.167 $N_{1,60}$
Estimating E_s from q_c (static cone resistance)		
Sandy soils		$0.028q_c$

ESU 2B Medium Dense Sand/ Gravel
Es = 4.6 ksi = 660 ksf
Poisson Ratio = 0.33

The modulus of elasticity for normally consolidated granular soils tends to increase with depth. An alternative method of defining the soil modulus for granular soils is to assume that it increases linearly with depth starting at zero at the ground surface in accordance with the following equation:

$$E_s = nh \times z \qquad \text{(C10.4.6.3-1)}$$

where:

Appendix F.3 - Wall 05.85L-B Design Calculations

AASHTO Average Blowcount in Upper 100 feet

Soil Profile Type	v_s (fps)	N
S_A	>5000	N/A
S_B	2,500 to 5,000	
S_C	1,200 to 2,500	>50
S_D	600 to 1,200	15≤N≤50
S_E	<600	<15

Table 3.10.3.1-1—Site Class Definitions from AASHTO

Name	Nave	Soil Profile Type
W-218-20	74.1	C
R2B-11-17	51.7	C
R2B-10-17	55.2	C

Note:

Blowcount Percent (Energy is input BC/60). This spreadsheet approximates the layer thickness based on a function with depth, however, depending on the layering of the log, it may be necessary for the user to input their own layer thicknesses (i.e., clay layer extends at 7.5 ft and the blowcounts need to be weighted to reflect that thickness).

Spreadsheet based on Section 3.10.3.1 of American Association of State Highway and Transportation Officials (AASHTO).

AASHTO Average Blowcount in Upper 100 feet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	W-218-20								R2B-11-17							
2	Depth	Field Blowcount	Energy Corrected Blowcount, N_i	Layer thickness d_i (feet)	Sum(d_i)	d_i/N_i	Sum(d_i/N_i)	N_{ave}	Depth	Field Blowcount	Energy Corrected Blowcount, N_i	Layer thickness di (feet)	Sum(di)	di/Ni	Sum(di/Ni)	Nave
3	2.5	68	68	3.75	100	0.06	1.3495	74.1	4	36	53	5.5	100	0.10	1.9	51.7
4	5	23	23	2.5		0.11			7	11	16	2.5		0.15		
5	7.5	25	25	2.5		0.10			9	13	19	2.5		0.13		
6	10	22	22	3.75		0.17			12	17	25	2.5		0.10		
7	15	65	65	5		0.08	Driving Energy	60%	14	15	22	3.5		0.16	Driving Energy	88%
8	20	120	100	5		0.05			19	18	27	5		0.19		
9	25	120	100	5		0.05			24	18	27	5		0.19		
10	30	120	100	5		0.05			29	150	100	5		0.05		
11	35	120	100	5		0.05			34	100	100	5		0.05		
12	40	300	100	5		0.05			39	100	100	5		0.05		
13	45	100	100	5		0.05			44	60	88	5		0.06		
14	50	79	79	5		0.06			49	300	100	5		0.05		
15	55	100	100	5		0.05			54	72	100	5		0.05		
16	60	100	100	5		0.05			59	49	72	43.5		0.60		
17	65	100	100	5		0.05								End of Data		
18	70	100	100	5		0.05								End of Data		
19	75	300	100	5		0.05								End of Data		
20	80	1200	100	22.5		0.23								End of Data		
21						End of Data								End of Data		
22						End of Data								End of Data		
23						End of Data								End of Data		
24						End of Data								End of Data		
25						End of Data								End of Data		
26						End of Data								End of Data		
27						End of Data								End of Data		
28						End of Data								End of Data		

AASHTO Average Blowcount in Upper 100 feet

	Q	R	S	T	U	V	W	X
1	R2B-10-17							
2	**Depth**	**Field Blowcount**	**Energy Corrected Blowcount, N_i**	**Layer thickness di (feet)**	**Sum(di)**	**di/Ni**	**Sum(di/Ni)**	**Nave**
3	4	51	75	5.5	100	0.07	1.8113	55.2
4	7	16	24	2.5		0.11		
5	9	12	18	2.5		0.14		
6	12	8	12	2.5		0.21		
7	14	21	31	3.5		0.11	Driving Energy	88%
8	19	48	71	5		0.07		
9	24	35	52	5		0.10		
10	29	50	74	73.5		1.00		
11						End of Data		
12						End of Data		
13						End of Data		
14						End of Data		
15						End of Data		
16						End of Data		
17						End of Data		
18						End of Data		
19						End of Data		
20						End of Data		
21						End of Data		
22						End of Data		
23						End of Data		
24						End of Data		
25						End of Data		
26						End of Data		
27						End of Data		
28						End of Data		
29								

05.85L-B

BEToolbox™

Spectra

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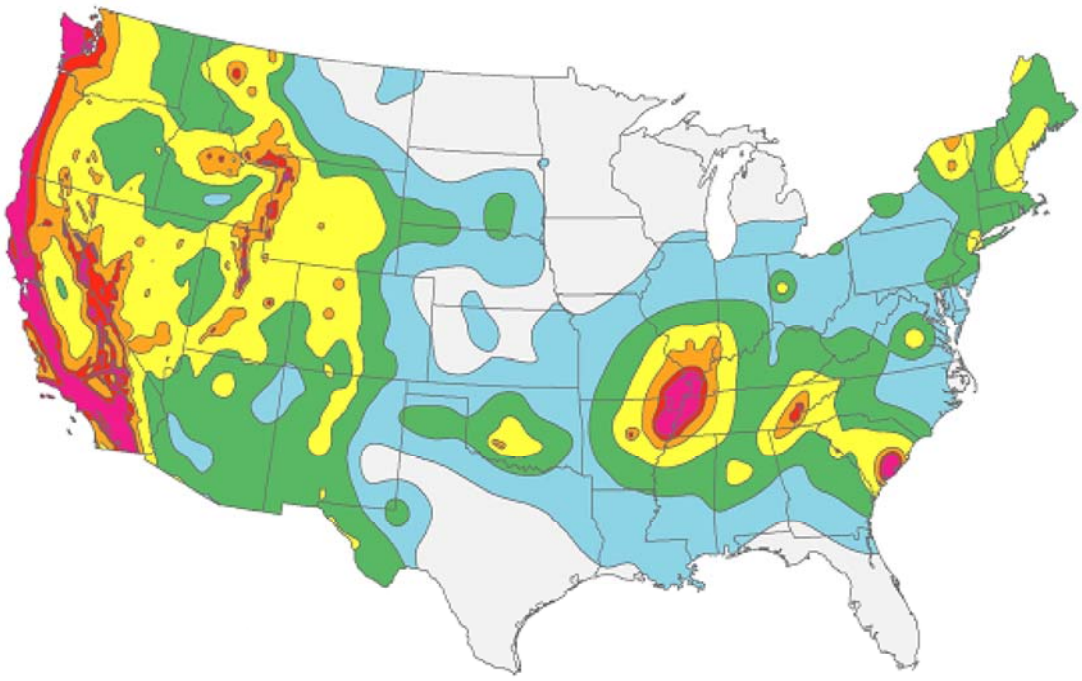
Version 6.0.0.6 BETA - Built on Jan 7 2021



05.85L-B

WSDOT Bridge Design Manual
2014 Seismic Hazard Map, 7% probability of exceedance in 75 years

Site Coordinates (Latitude,Longitude): 47.5109° N, 122.198° W
Site Soil Classification: Site Class C - Very Dense Soil and Soft Rock

Seismic hazard maps are for sites at the boundary of Site Classes B and C, which is $\bar{v}_s$ = 2500 ft/s (760 m/s). Adjustments for other Site Classes are made as needed.

Period (sec)	Sa (g)	
0.0	0.433	PGA - Site Class B/C Boundary
0.2	0.987	S_s - Site Class B/C Boundary
1.0	0.283	S_1 - Site Class B/C Boundary

Values of Site Coefficient, F_{pga}, for Peak Ground Acceleration

Site Class	Mapped Peak Ground Acceleration Coefficient (PGA)					
	PGA≤ 0.10	PGA= 0.20	PGA= 0.30	PGA= 0.40	PGA= 0.50	PGA≥ 0.60
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.2	1.2	1.2	1.2	1.2
D	1.6	1.4	1.3	1.2	1.1	1.1
E	2.4	1.9	1.6	1.4	1.2	1.1

For Site Class C, F_{pga} = 1.200

Values for Site Coefficient, F_a, for 0.2 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 0.2 sec (S_s)					
	S_s≤ 0.25	S_s= 0.50	S_s= 0.75	S_s= 1.00	S_s= 1.25	S_s≥ 1.50
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.9	0.9	0.9	0.9	0.9	0.9
C	1.3	1.3	1.2	1.2	1.2	1.2
D	1.6	1.4	1.2	1.1	1.0	1.0
E	2.4	1.7	1.3	1.0	0.9	0.9

For Site Class C, F_a = 1.200

Values of Site Coefficient, F_v, for 1.0 sec Period Spectral Acceleration

Site Class	Mapped Spectral Acceleration Coefficient at Period 1.0 sec (S_1)					
	S_1≤ 0.1	S_1= 0.2	S_1= 0.3	S_1= 0.4	S_1= 0.5	S_1≥ 0.6
A	0.8	0.8	0.8	0.8	0.8	0.8
B	0.8	0.8	0.8	0.8	0.8	0.8
C	1.5	1.5	1.5	1.5	1.5	1.4
D	2.4	2.2	2.0	1.9	1.8	1.7
E	4.2	3.3	2.8	2.4	2.2	2.0

For Site Class C, F_v = 1.500

$A_s = F_{pga}$ PGA = (1.200)(0.433g) = 0.520g
$S_{DS} = F_a S_s$ = (1.200)(0.987g) = 1.184g
$S_{D1} = F_v S_1$ = (1.500)(0.283g) = 0.425g
$T_o = 0.2T_s$ = (0.2)(0.359) = 0.072 sec
$T_s = S_{D1}/S_{DS}$ = (0.425)/(1.184) = 0.359 sec

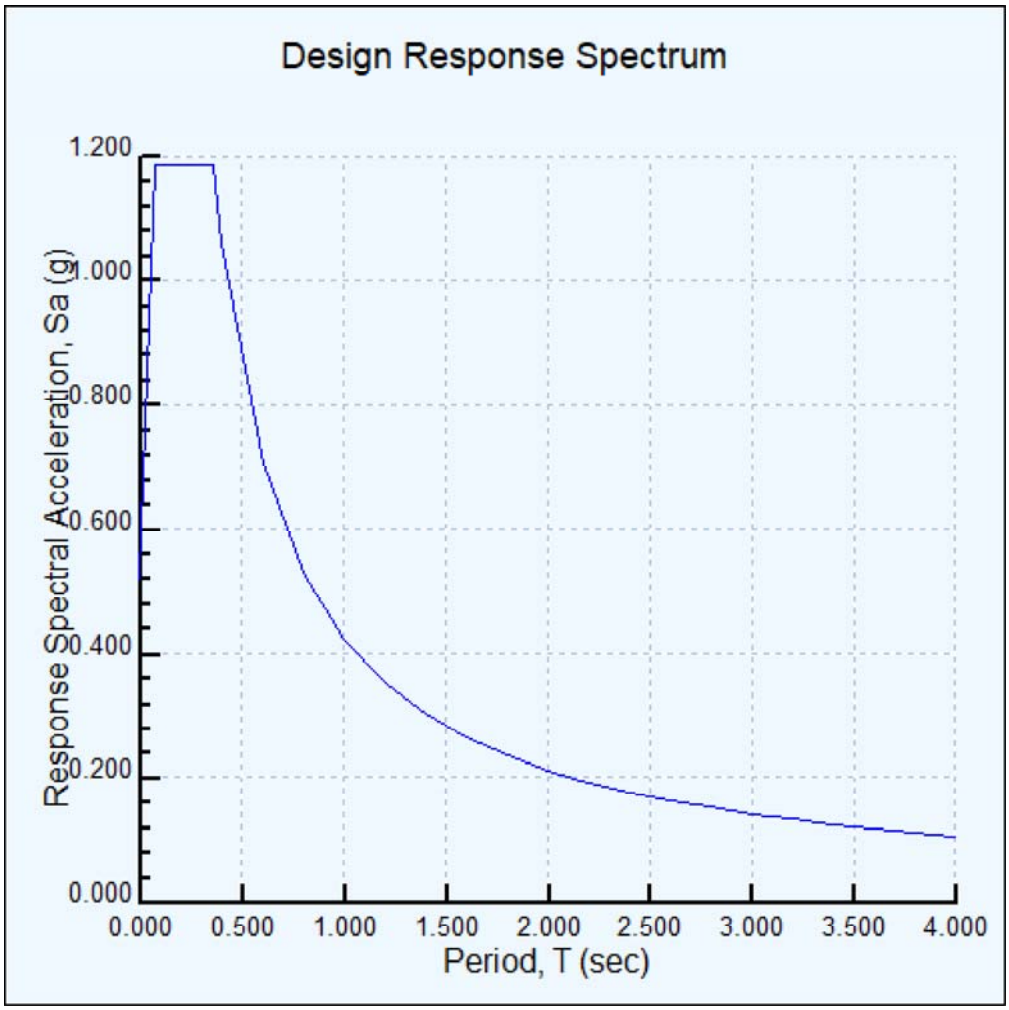
05.85L-B

Partitions for Seismic Design Categories A, B, C, and D

S_{D1}	SDC
$S_{D1} < 0.15$	A
$0.15 \le S_{D1} < 0.30$	B
$0.30 \le S_{D1} < 0.50$	C
$0.50 \le S_{D1}$	D

Seismic Design Category (SDC) = C

Period, T (sec)	Sa (g)	
0.000	0.520	
0.072	1.184	T_o
0.200	1.184	
0.359	1.184	T_s
0.400	1.062	
0.600	0.708	
0.800	0.531	
1.000	0.425	
1.200	0.354	
1.400	0.303	
1.600	0.265	
1.800	0.236	
2.000	0.212	
2.200	0.193	
2.400	0.177	
2.600	0.163	
2.800	0.152	
3.000	0.142	
3.200	0.133	
3.400	0.125	
3.600	0.118	
3.800	0.112	
4.000	0.106	



Calculating Wall Seismic Acceleration Considering Wave Scattering for Wall 05.85L-B

Per National Cooperative Highway Research Program (NCHRP) Report 611 the site class adjusted peak ground acceleration (PGA), As, can be corrected to account for vertical variations in the average ground acceleration observed behind tall retaining walls and/ or slopes greater than 20-feet in height by applying a wall height acceleration reduction factor (or α coefficient) to the As.

Site Class D

$M := 6.97$ Mean earthquake magnitude at the PGA period based on the Hart Crowser seismic design report "I-405 R2B Segment 1a Site-Specific Hazard Analysis RFU," dated March 25, 2021.

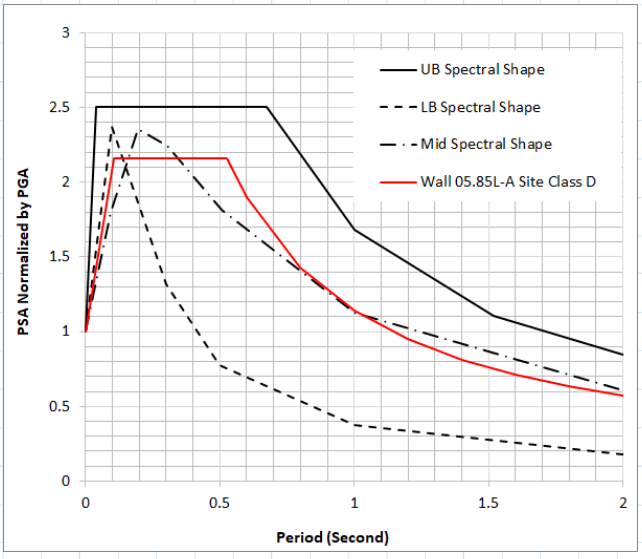
Determine response spectrum using WSDOT Bridge Engineering Software BEToolbox/ BridgeLink Version 6.0.0.6 BETA in accordance with the WSDOT BDM based on the projected ground motion at the project site that has a 7 percent (SEE) probability of exceedance in a 75-year period (approximate 1,000-year return period).

$A_s := 0.520$ (g) Site Class Adjusted PGA

$S_{D1} := 0.425$

Determine the most appropriate spectral curve shape based on NCHRP Report 611 Figure 5-4.

1. Normalize response spectrum by the peak ground acceleration (PGA).
2. The peak spectral acceleration (PSA) normalized by PGA is then overlaid on the spectral shapes shown on Figure 5-4 to determine the most appropriate spectral curve shape for the design condition. Three spectral shapes shown on Figure 5-4 include an upper bound (UB), lower bound (LB), and intermediate (Mid) spectral shape.



The Mid spectral shape was selected.

Determine wall height acceleration reduction factor (or α coefficient) using wall height and the spectral shapes based on NCHRP Report 611 Figure 6-13.

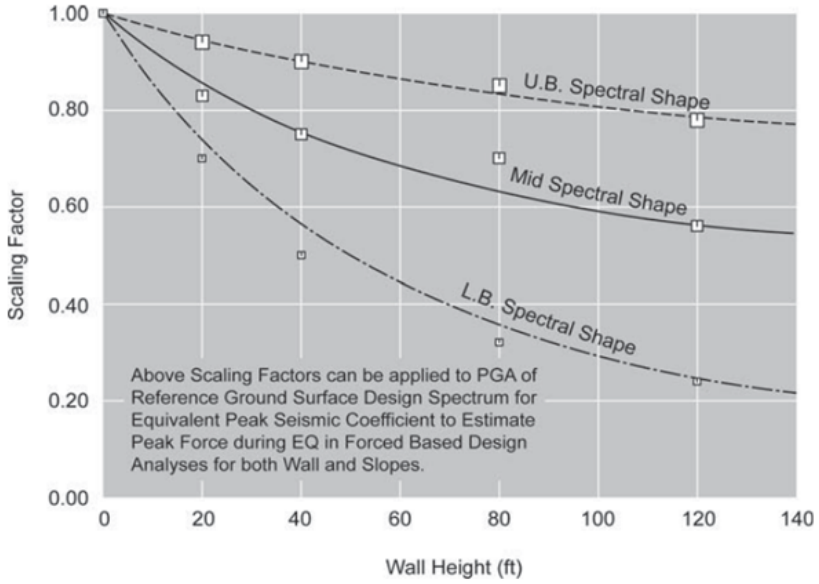


Figure 6-13. Resultant wave scattering α coefficients for retaining wall design.

Station 2+60 (Current design)

For Lateral Earth Pressure calculations, slope height is taken as 30 ft. (vertical distance between proposed ground surface prior to Forward Compatible Wall construction and SEW wall base at the back of wall heel) The wall height acceleration reduction factor selected from Figure 6-13 is:

$$\alpha := 0.808$$

Wall seismic acceleration considering wave scattering

$$PGA_a := A_s \cdot \alpha = 0.42$$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$$k_h := \frac{PGA_a}{2} = 0.210$$

For Compound Stability calculations, the slope height is taken as 32 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$\alpha := 0.799$

Wall seismic acceleration considering wave scattering

$PGA_a := A_s \cdot \alpha = 0.415$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$k_h := \frac{PGA_a}{2} = 0.208$

For Global Stability calculations, the slope height is taken as 43.5 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$\alpha := 0.755$

Wall seismic acceleration considering wave scattering

$PGA_a := A_s \cdot \alpha = 0.393$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$k_h := \frac{PGA_a}{2} = 0.196$

Station 2+60 (with Forward Compatible Wall)

For Compound Stability calculations, the slope height is taken as 44 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$\alpha := 0.753$

Wall seismic acceleration considering wave scattering

$PGA_a := A_s \cdot \alpha = 0.392$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$k_h := \frac{PGA_a}{2} = 0.196$

For Global Stability calculations, the slope height is taken as 43 ft based on the height of the critical failure surface (refer to Slope/W figures). The wall height acceleration reduction factor selected from Figure 6-13 is:

$$\alpha := 0.756$$

Wall seismic acceleration considering wave scattering

$$PGA_a := A_s \cdot \alpha = 0.393$$

Horizontal seismic coefficient for use in pseudo-static slope stability analyses

$$k_h := \frac{PGA_a}{2} = 0.197$$

General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	W-218-20
Analysis by:	BZ
Date Analyzed:	4/8/2021
Checked by:	TB
Date Checked:	4/8/2021

Sampling Information	
Depth to Groundwater (ft):	28.6
SPT Liner (Yes/No):	No
Hammer Energy, %:	60
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	6

Earthquake Information	
Max Acceleration (As) (g) :	0.520
Earthquake Magnitude:	6.97

GW based on SEEP/W analysis at Wall 05.85L-A

Site Class C SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Collect Data From gINT

Auto %F from USCS

Auto %F from WSDOT GDM

COMPUTE

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	2.5	68	SW-SM	9	ESU 1B	125		Unsaturated	
	5.0	23	SM	33	ESU 2B	115		Unsaturated	
	7.5	25	SM	33	ESU 2B	120		Unsaturated	
	10.0	22	SM	33	ESU 2B	115		Unsaturated	
	15.0	65	SM	41	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	20.0	120	SM	45	ESU 4B	130	3.0	Non-Liquefiable	Non-Liquefiable
	25.0	120	SM	36	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	30.0	120	SM	36	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	35.0	120	SP	5	ESU 4B	125		Non-Liquefiable	Non-Liquefiable
	40.0	300	SP	5	ESU 4B	125		Non-Liquefiable	Non-Liquefiable
	45.0	100	ML	98	ESU 5B	130	8.0	Non-Liquefiable	Non-Liquefiable
	50.0	79	ML	98	ESU 5B	130		Non-Liquefiable	Non-Liquefiable
	55.0	100	CL	95	ESU 5B	130	13.0	Non-Liquefiable	Non-Liquefiable
	60.0	100	CL	95	ESU 5B	130		Non-Liquefiable	Non-Liquefiable
	65.0	100	SM	15	ESU 4B	135		Non-Liquefiable	Non-Liquefiable
	70.0	100	SM	15	ESU 4B	135		Non-Liquefiable	Non-Liquefiable
	75.0	300	GM	25	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	80.0	1200	GM	25	ESU 4B	130		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	2.5	68	SW-SM	9	96	97	2.00	2.00	0.0	0.0	0.0	0.0	97.0	99.7	95.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	5.0	23	SM	33	31	32	2.00	2.00	0.0	0.0	0.0	0.0	31.5	36.0	29.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.5	25	SM	33	31	30	2.00	2.00	0.0	0.0	0.0	0.0	30.4	35.3	29.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	10.0	22	SM	33	27	26	2.00	2.00	0.0	0.0	0.0	0.0	26.3	28.7	25.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	15.0	65	SM	41	76	74	2.00	2.00	0.0	0.0	0.0	0.0	73.7	76.2	73.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	20.0	120	SM	45	101	105	2.00	2.00	0.0	0.0	0.0	0.0	125.6	120.9	121.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	25.0	120	SM	36	90	99	2.00	2.00	0.0	0.0	0.0	0.0	118.2	107.7	111.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	30.0	120	SM	36	86	99	2.00	2.00	0.0	0.0	0.0	0.0	119.1	104.4	109.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	35.0	120	SP	5	82	97	2.00	2.00	0.0	0.0	0.0	0.0	116.6	100.2	106.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	40.0	300	SP	5	78	95	2.00	2.00	0.0	0.0	0.0	0.0	285.8	241.3	256.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	45.0	100	ML	98	74	93	2.00	2.00	0.0	0.0	0.0	0.0	93.4	77.5	82.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	50.0	79	ML	98	56	72	2.00	2.00	0.0	0.0	0.0	0.0	72.4	59.1	63.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	55.0	100	CL	95	68	90	2.00	2.00	0.0	0.0	0.0	0.0	90.1	72.4	77.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	60.0	100	CL	95	65	89	2.00	2.00	0.0	0.0	0.0	0.0	88.7	70.2	75.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	65.0	100	SM	15	62	87	2.00	2.00	0.0	0.0	0.0	0.0	87.3	68.1	72.7	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	70.0	100	SM	15	60	86	2.00	2.00	0.0	0.0	0.0	0.0	85.9	66.1	70.5	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	75.0	300	GM	25	58	85	2.00	2.00	0.0	0.0	0.0	0.0	254.3	193.3	205.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	80.0	1200	GM	25	56	84	2.00	2.00	0.0	0.0	0.0	0.0	1004.3	754.5	799.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

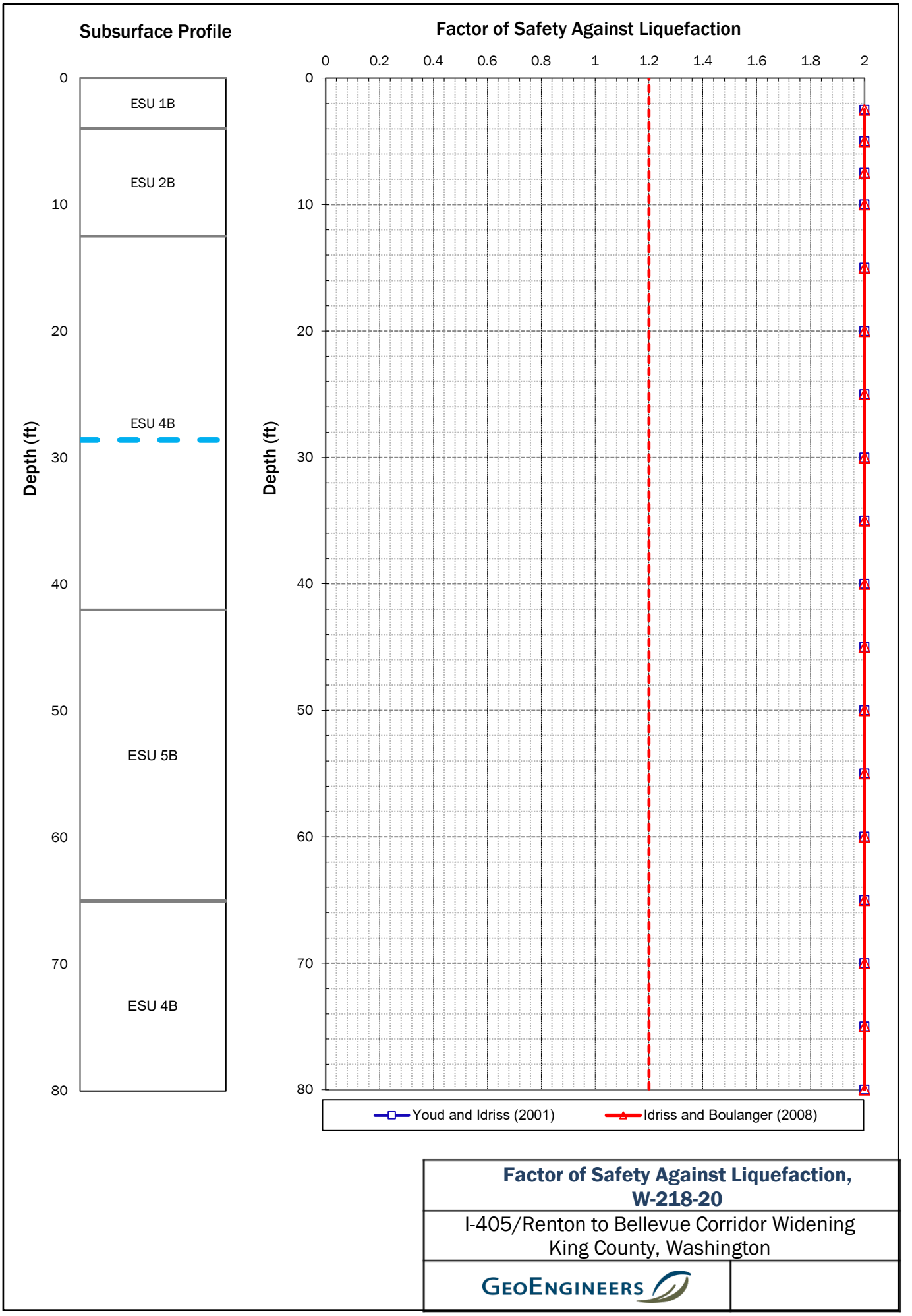
Seismic Parameters	
Max Acceleration (As) (g) :	0.520
Earthquake Magnitude:	6.97

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, W-218-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

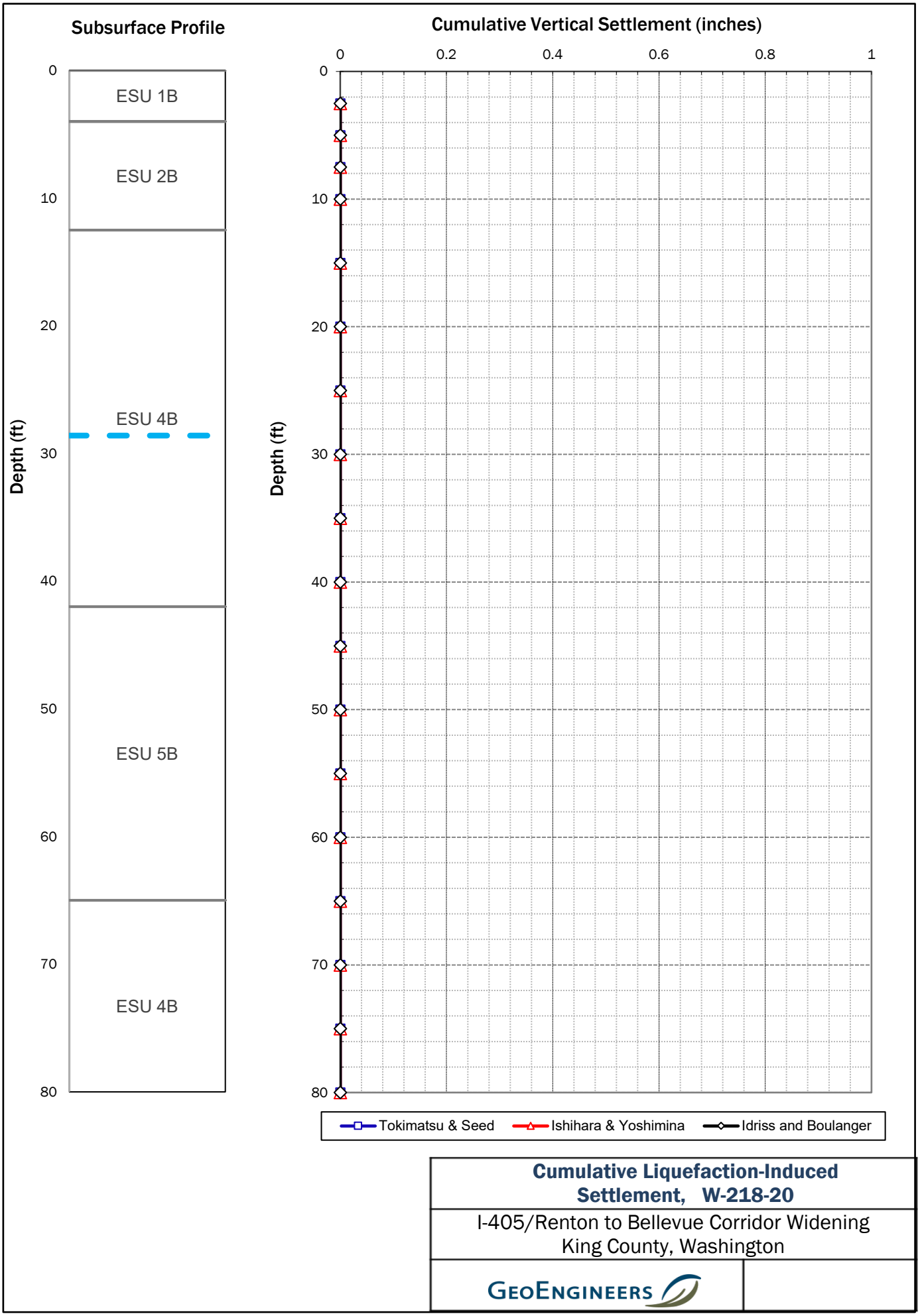


Factor of Safety Against Liquefaction, W-218-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/8/2021



Cumulative Liquefaction-Induced Settlement, W-218-20

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/8/2021

General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	R2B-10-17
Analysis by:	BZ
Date Analyzed:	4/8/2021
Checked by:	TB
Date Checked:	4/9/2021

Sampling Information	
Depth to Groundwater (ft):	16.2
SPT Liner (Yes/No):	No
Hammer Energy, %:	88.4
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	4

Earthquake Information	
Max Acceleration (As) (g) :	0.520
Earthquake Magnitude:	6.97

GW based on SEEP/W analysis at Wall 05.85L-A

Site Class C SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Collect Data From gINT

Automate %F from USCS

Auto %F from WSDOT GDM

COMPUTE

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	4.0	51	SM	35	ESU 1B	130		Unsaturated	
	7.0	16	SM	35	ESU 2B	110		Unsaturated	
	9.0	12	SM	35	ESU 2B	110		Unsaturated	
	12.0	8	ML	70	ESU 2B	110		Unsaturated	
	14.0	21	SM	15	ESU 2B	115			
	19.0	48	SM	15	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	24.0	35	SM	15	ESU 4B	120		Non-Liquefiable	Non-Liquefiable
	29.0	50	SM	15	ESU 4B	130		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	4.0	51	SM	35	86	82	2.00	2.00	0.0	0.0	0.0	0.0	81.5	95.8	81.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.0	16	SM	35	26	26	2.00	2.00	0.0	0.0	0.0	0.0	26.0	29.8	24.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	9.0	12	SM	35	19	20	2.00	2.00	0.0	0.0	0.0	0.0	19.7	21.1	18.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	12.0	8	ML	70	12	12	2.00	2.00	0.0	0.0	0.0	0.0	12.1	12.3	11.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	14.0	21	SM	15	29	29	2.00	2.00	0.0	0.0	0.0	0.0	28.8	30.0	28.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	19.0	48	SM	15	67	67	2.00	2.00	0.0	0.0	0.0	0.0	67.3	67.4	66.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	24.0	35	SM	15	46	47	2.00	2.00	0.0	0.0	0.0	0.0	47.4	46.1	46.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	29.0	50	SM	15	65	69	2.00	2.00	0.0	0.0	0.0	0.0	68.9	64.8	66.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

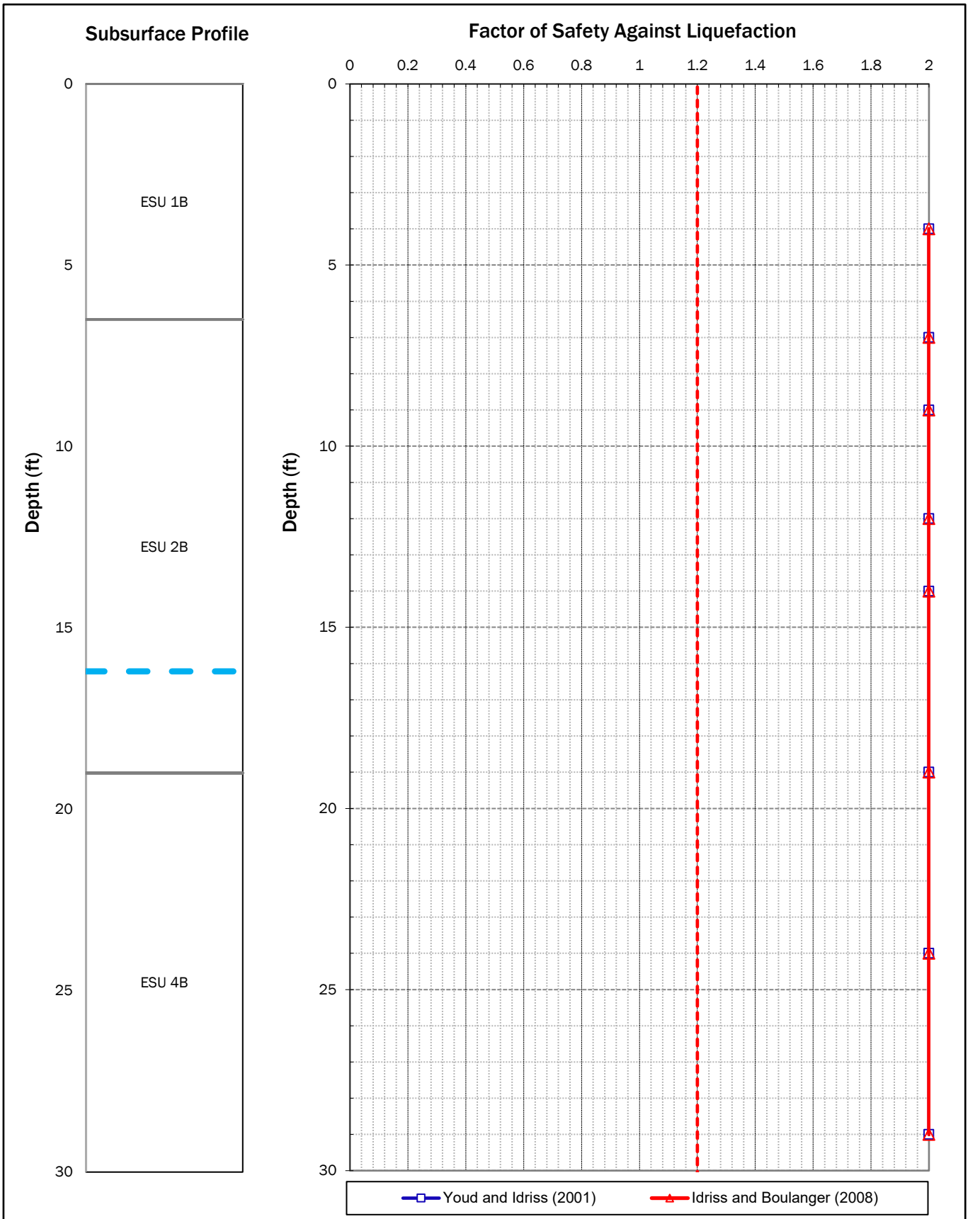
Seismic Parameters	
Max Acceleration (As) (g) :	0.520
Earthquake Magnitude:	6.97

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, R2B-10-17

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

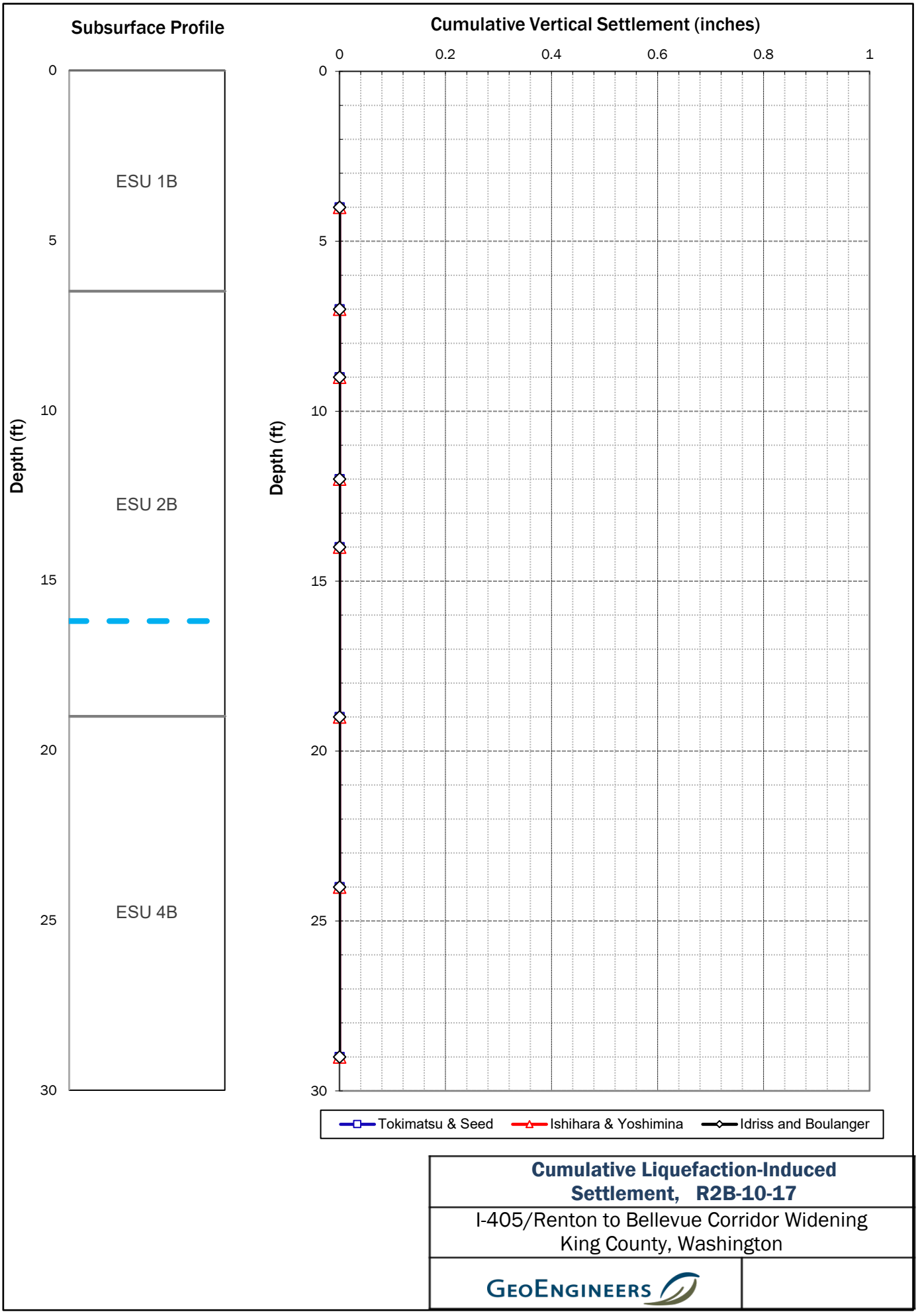


Factor of Safety Against Liquefaction, R2B-10-17

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/9/2021



Cumulative Liquefaction-Induced Settlement, R2B-10-17

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 4/9/2021

General Information	
Project:	I-405/Renton to Bellevue Corridor Widening
Project Location:	King County, Washington
Job Number:	00180-366-01
Boring Designation:	R2B-11-17
Analysis by:	BZ
Date Analyzed:	4/8/2021
Checked by:	TB
Date Checked:	4/9/2021

Sampling Information	
Depth to Groundwater (ft):	20.2
SPT Liner (Yes/No):	No
Hammer Energy, %:	88.4
Distance from sample hammer to ground/mudline surface (ft):	5
Borehole Diameter (in)	4

Earthquake Information	
Max Acceleration (As) (g) :	0.520
Earthquake Magnitude:	6.97

GW based on SEEP/W analysis at Wall 05.85L-A

Site Class C SEE

Title Block Information	
Line 1:	I-405/Renton to Bellevue Corridor Widening
Line 2:	King County, Washington

gINT Collection Information	
P-Drive File Path to gINT database:	
Boring Selected from Database:	

Residual Strength Weighting	
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0.0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

User Input

gINT or User Input

Fine -Grain Soil Susceptibility	
PI Cutoff Value:	12

Collect Data From gINT

Automate %F from USCS

Auto %F from WSDOT GDM

COMPUTE

*You must hit "COMPUTE" again anytime you change any of the blue or purple inputs. If the output tab is blank or has errors hit "COMPUTE" again.

SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Geologic Unit/ ESU	Unit Weight (pcf)	PI (%)	Non-liquefiable (i.e. "unstaturated", "cohesive",etc)	User Override*
	4.0	36	SM	29	ESU 1B	120		Unsaturated	
	7.0	11	SM	29	ESU 2B	110	0.0	Unsaturated	
	9.0	13	SM	29	ESU 2B	110		Unsaturated	
	12.0	17	SM	29	ESU 2B	115		Unsaturated	
	14.0	15	SM	29	ESU 2B	110		Unsaturated	
	19.0	18	ML	97	ESU 2B	110			
	24.0	18	ML	97	ESU 2B	115	3.0		
	29.0	150	SC	22	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	34.0	100	SC	22	ESU 4B	130	9.0	Non-Liquefiable	Non-Liquefiable
	39.0	100	SC	22	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	44.0	60	SC	22	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	49.0	300	SC	22	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	54.0	72	SM	18	ESU 4B	130		Non-Liquefiable	Non-Liquefiable
	59.0	49	SM	18	ESU 4B	130		Non-Liquefiable	Non-Liquefiable

*User Override column is ***NOT*** required to be filled out, unless needed. See "Read Me" tab.

					Liquefaction Analysis								Residual Shear Strength Analysis							
					$N_{1,60}$		Liquefaction Factor of Safety		Liquefaction-Induced Settlement (in)			LDI (ft)	$N_{1,60}$			Residual Shear Strength, Sr (psf)				
SPT Sample Number	Depth (ft)	Measured N	USCS	Fines Content (%)	Youd and Idriss (2001)	Idriss and Boulanger (2008)	Youd and Idriss (2001)	Idriss and Boulanger (2014)	Tokimatsu & Seed	Ishihara & Yoshimine	Idriss and Boulanger	Idriss and Boulanger	Idriss & Boulanger Void Distribution (2007)	Olsen & Stark (2002)	Kramer & Wang Hybrid (2008)	WSDOT	Olsen & Stark (2002)	Idriss & Boulanger Void Redistribution (2007)	Idriss & Boulanger No Void Redistribution (2007)	Kramer & Wang Hybrid (2008)	Idriss et al. (1998)
	4.0	36	SM	29	61	59	2.00	2.00	0.0	0.0	0.1	0.1	58.8	67.6	58.8	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	7.0	11	SM	29	18	19	2.00	2.00	0.0	0.0	0.1	0.1	19.1	21.0	16.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	9.0	13	SM	29	21	22	2.00	2.00	0.0	0.0	0.1	0.1	21.5	23.3	19.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	12.0	17	SM	29	25	25	2.00	2.00	0.0	0.0	0.1	0.1	24.9	26.4	24.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	14.0	15	SM	29	21	21	2.00	2.00	0.0	0.0	0.1	0.1	21.0	21.6	20.2	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	19.0	18	ML	97	25	25	2.00	1.97	0.0	0.0	0.1	0.1	25.1	25.0	24.6	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	24.0	18	ML	97	23	24	2.00	1.50	0.0	0.0	0.1	0.1	23.8	23.3	23.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	29.0	150	SC	22	128	137	2.00	2.00	0.0	0.0	0.0	0.0	204.9	191.4	196.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	34.0	100	SC	22	120	133	2.00	2.00	0.0	0.0	0.0	0.0	132.6	120.6	125.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	39.0	100	SC	22	114	129	2.00	2.00	0.0	0.0	0.0	0.0	129.1	114.6	120.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	44.0	60	SC	22	65	76	2.00	2.00	0.0	0.0	0.0	0.0	75.6	65.7	69.3	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	49.0	300	SC	22	102	123	2.00	2.00	0.0	0.0	0.0	0.0	369.7	314.8	334.1	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	54.0	72	SM	18	70	87	2.00	2.00	0.0	0.0	0.0	0.0	86.9	72.7	77.4	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	59.0	49	SM	18	45	58	2.00	2.00	0.0	0.0	0.0	0.0	58.0	47.7	50.9	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

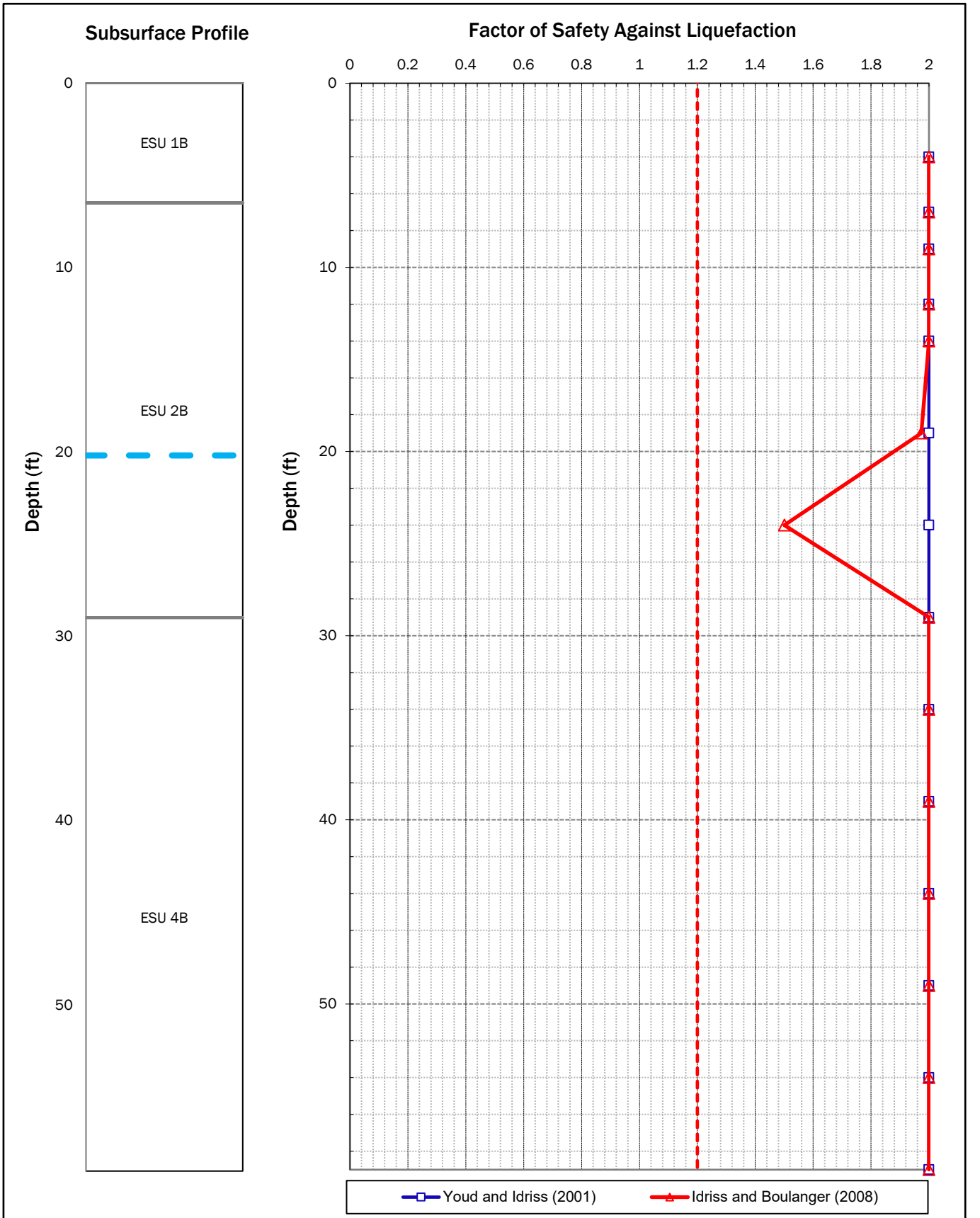
Seismic Parameters	
Max Acceleration (As) (g) :	0.520
Earthquake Magnitude:	6.97

Residual Strength Weighting Factors	
WSDOT:	0
Olsen & Stark (2002):	0.2
Idriss & Boulanger Void Redistribution (2007):	0.2
Idriss & Boulanger No Void Redistribution (2007):	0
Kramer, Wang Hybrid (2008):	0.4
Idriss et al. (1998):	0.2

Liquefaction and Residual Shear Strength Analysis Results, R2B-11-17

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

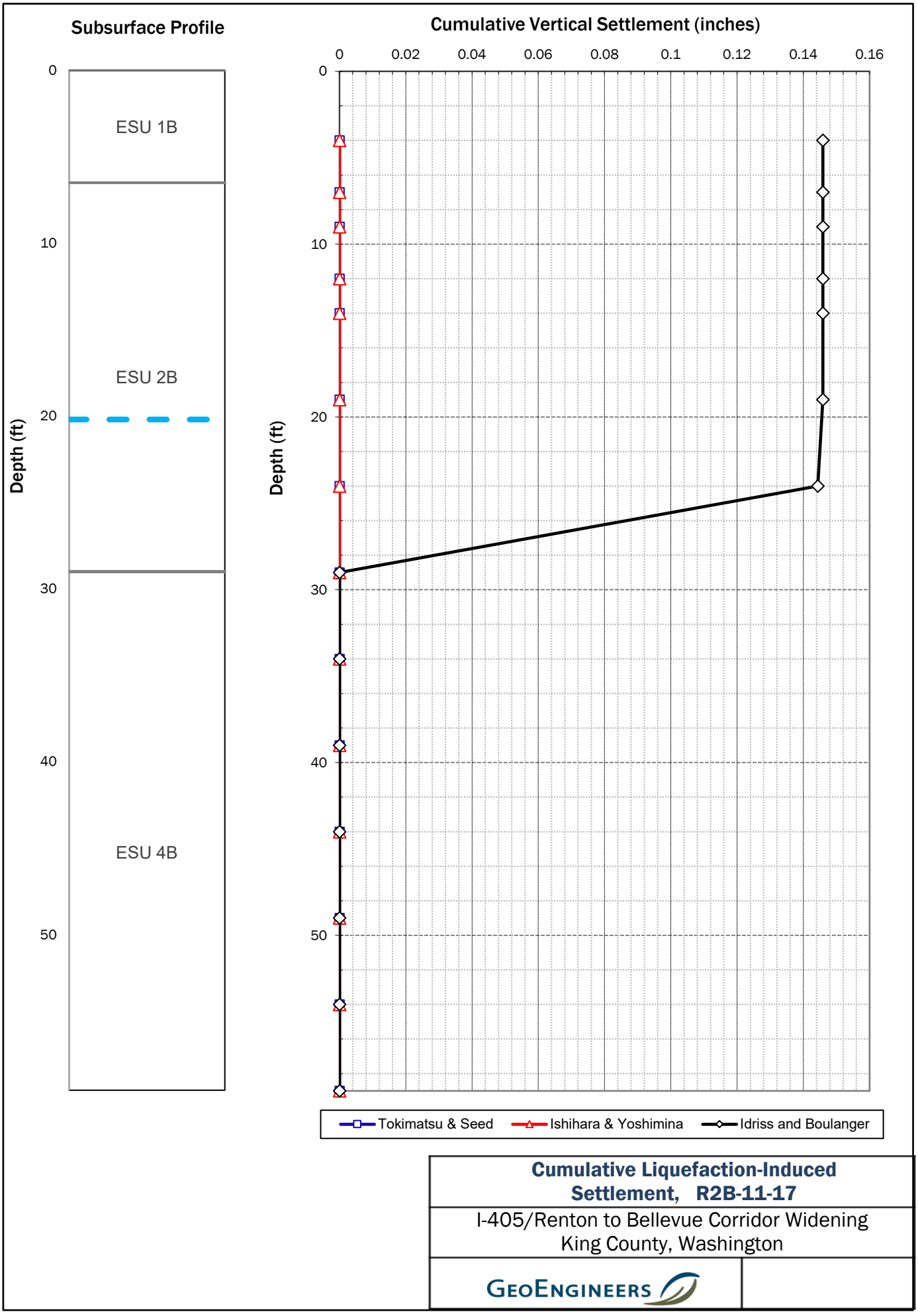


Factor of Safety Against Liquefaction, R2B-11-17

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 1/0/1900



Cumulative Liquefaction-Induced Settlement, R2B-11-17

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01; Date Checked: 1/0/1900

Lateral Earth Pressures for Cohesionless Soils

Project Information

Project:	I-405/Renton to Bellevue Corridor Widening
Owner:	WSDOT
Job Number:	00180-366-01
Analysis by:	YTT
Date/Time:	1/11/2022 3:35 PM
Checked by:	TB

Input Parameters

Material	ϕ Friction Angle (deg)	β_2 (-) Foreslope (deg)	i (+) Backslope (deg)	δ Wall Friction - Active (deg)	δ Wall Friction - Passive (deg)	β Wall Batter (deg)	γ_m (pcf)	γ_b (pcf)	Passive Factor of Safety	k_h (g)	k_v (g)
ESU 2B	34	-15	27	23	0	0	115	52.6	1	0	0

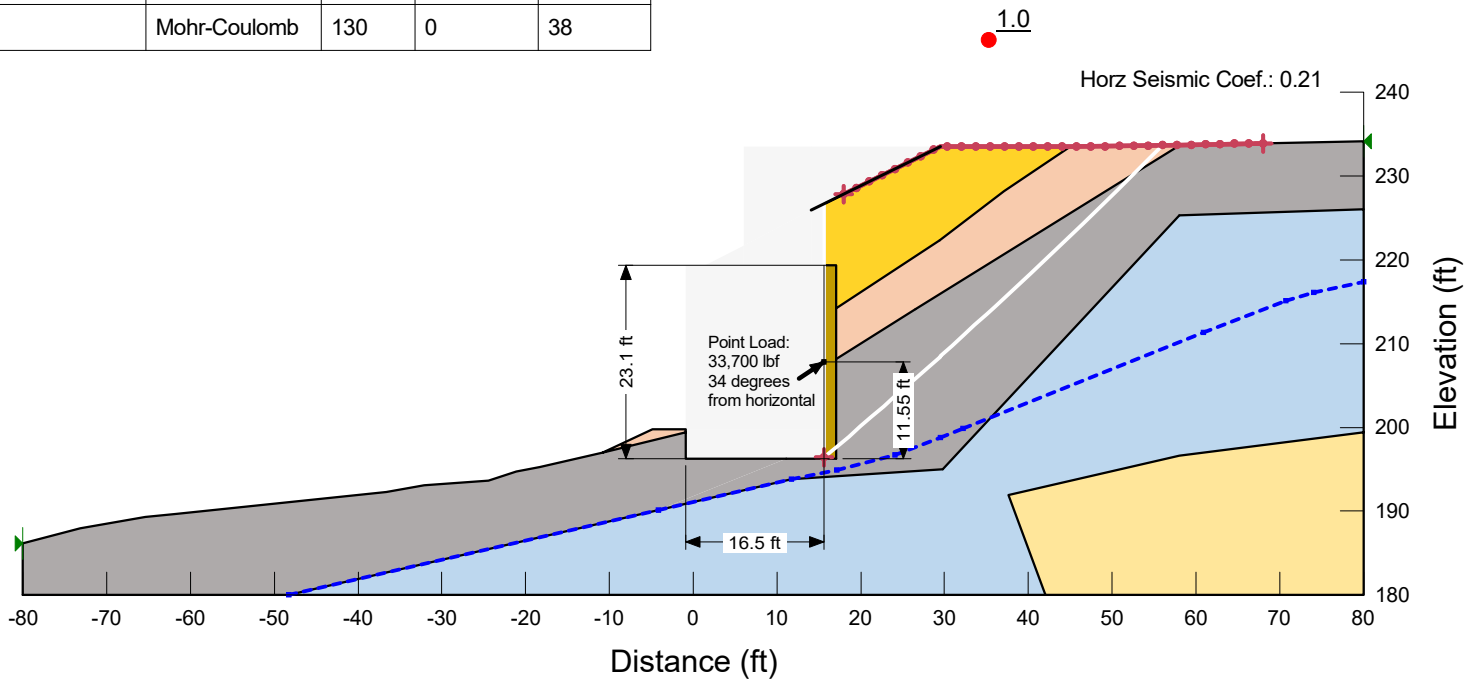
Lateral Earth Pressures

Output

Material	Active			Passive					At Rest			Apparent EP Trapezoid		Seismic				Seismic Pressure - Rectangular
	K_a	γ_a (pcf)	γ'_a (pcf)	K_p	$\gamma_{p(all)}$ (pcf)	$\gamma'_{p(all)}$ (pcf)	$\gamma_{pe(all)}$ (pcf)	$\gamma'_{pe(all)}$ (pcf)	K_o	γ_o (pcf)	γ'_o (pcf)	Single Tieback (psf * H)	Mult. Tiebacks[1], X	K_{ae}	γ_{ae} (pcf)	γ'_{ae} (pcf)	K_{pe}	(psf * H)
ESU 2B	0.41	46.87	21.44	2.15	246.85	112.91	742.90	339.80	0.44	50.69	23.19	46.87	46.87	0.41	46.87	21.44	6.46	0.00

Recommended Lateral Earth Pressures

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38



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Wall 05.85L-B - Sta. 2+60
LEP - GLE Approach (Spencer, 1/2H)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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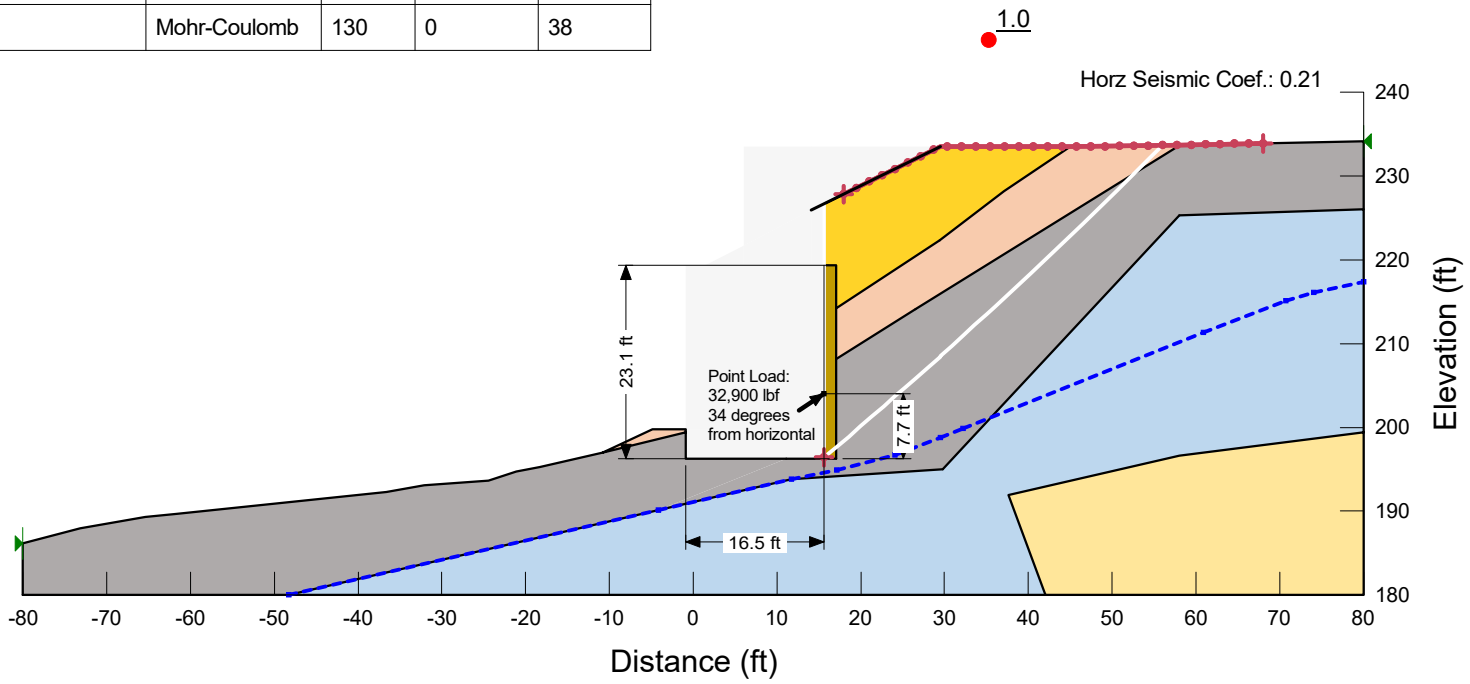
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38



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Wall 05.85L-B - Sta. 2+60
LEP - GLE Approach (Spencer, 1/3H)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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Seismic Earth Pressure Calculation Wall 05.85L-B

Active and seismic earth pressures using the limit equilibrium method outlined in NCHRP Report 611 Section 4.2.1 (Anderson et al., 2008) per AASHTO A11.3.3.

Earth pressures were developed from the bottom of footing to ground surface. Different application location of the force at one-third from the base (1/3H, where H is retained soil height) and at one half from the base were examined to determine the maximum seismic earth pressure. Spencer's methods was used to verify Pa and Pae.

Friction angle of the ESU 2B is used to define the inclination fo the applied point load in the model.

$\phi := 34\ °$ Friction angle of ESU 2B

$P_{AE2} := 33700\ \frac{lbf}{ft}$ Location of force = 1/2H

$P_{AE3} := 32900\ \frac{lbf}{ft}$ Location of force = 1/3H

(See slopeW output attached)

Given: $\gamma := 115\ pcf$ $H := 23.1\ ft$ Height of wall

$k_v := 0$ $k_h := 0.21$ Half of PGA applied for flexible system, PGA reduced to 0.42g for wave scatter effects.

$K_{AE2} := \frac{P_{AE2} \cdot 2}{\gamma \cdot H^2 \cdot (1 - k_v)} = 1.1$ Location of force = 1/2H

$K_{AE3} := \frac{P_{AE3} \cdot 2}{\gamma \cdot H^2 \cdot (1 - k_v)} = 1.07$ Location of force = 1/3H

Seismic+active earth pressures

$$\max(\gamma \cdot K_{AE2}, \gamma \cdot K_{AE3}) = 126\ \frac{lbf}{ft^3}$$

Sliding Coefficients of Friction

Foundation Soil Type	φ'	Discontinuous Reinforcements
ESU 2B	34	0.67
Common Borrow	32	0.62
Select Borrow	36	0.73
Gravel Borrow	38	0.78

Notes:

Sliding coefficients calculated according to AASHTO Equation 10.6.3.4-2

Structural Earth Walls (SEW) are termed Mechanically Stabilized Earth (MSE) walls in AASHTO.

Coefficient of Friction for Discontinuous Reinforcements, e.g., Strips:

Coefficient of friction = 1.0*tan(Phi')

Phi' = lesser of friction angle of foundation soil and friction angle of reinforced fill per AASHTO 11.10.5.3

AASHTO 10.6.3.4:

$$R_\tau = CV \tan \phi_f \qquad (10.6.3.4\text{-}2)$$

for which:

C = 1.0 for MSE Wall per AASHTO Table 11.5.7-1

where:

ϕ_f = internal friction angle of drained soil (degrees)

V = total vertical force (kips)

LRFD Foundation Design

Spreadsheet Reference Section 10.6.3.1.2 of The 2014 AASHTO LRFD Bridge Design Specifications

Date/Time:	1/11/22 11:07 AM
Project Name:	**I-405/Renton to Bellevue Corridor Widening - Wall 05.85L-B (ESU 2B)**
Project No.:	**00180-366-01**

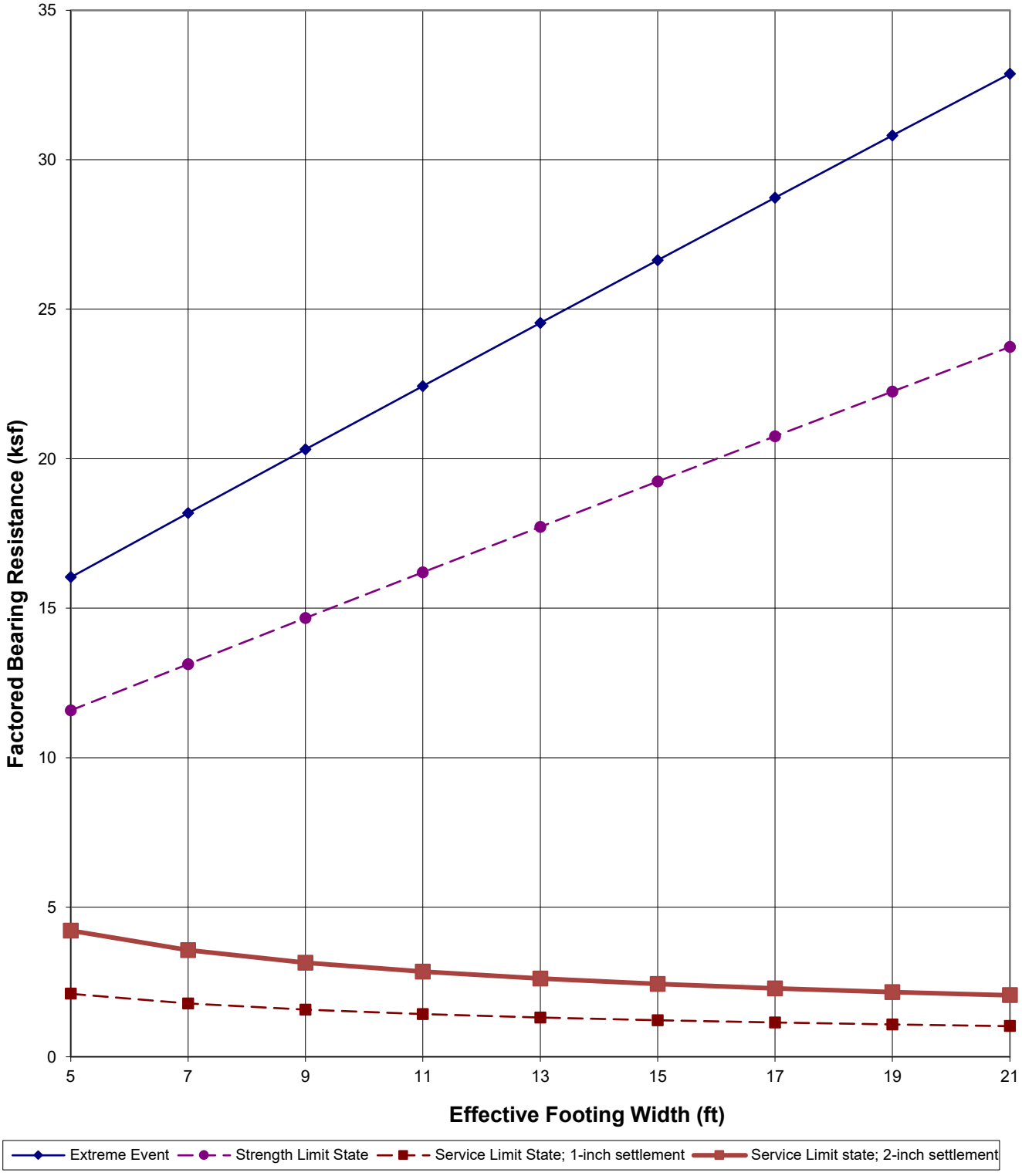
Foundation Soil Conditions	
Unit Weight, γ (pcf)	**115**
Friction angle, Φ (degrees)	**34**
Friction angle, Φ (rad)	0.593
Cohesion, C (psf)	**0**
Embedment, D_f (ft)	**3.5**
Depth to Groundwater, D_w (ft)	**1.8**
Footing Length, L (ft)	**340**
Footing Width, B (ft)	**1**
Poissons Ration, ν	**0.33**
Young's Modulus, E_s (ksf)	**660**

Bearing Capacity Factors	
N_γ	41
N_c	42
N_q	29

Effective Footing Width, B	**Water Depth Factors**		**Shape Factors**			**Unfactored Bearing Resistance**	**Extreme Event Resistance** Resistance Factor (0.9) for MSE walls (Section 11.5.8 AASHTO)	**Working Bearing Resistance** Resistance Factor (0.65) for MSE walls (Table Table 11.5.7-1)	Deflection from Elastic Settlement Spreadsheet **1" Deflection**	Deflection from Elastic Settlement Spreadsheet **2" Deflection**
	C_{wq}	$C_{w\gamma}$	Sc	S_γ	Sq					
(ft)						(ksf)	(ksf)	(ksf)	(ksf)	(ksf)
5.0	1.0	0.5	1.01	0.99	1.01	17.8	16.0	11.6	2.1	4.2
7.0	1.0	0.5	1.01	0.99	1.01	20.2	18.2	13.1	1.8	3.6
9.0	1.0	0.5	1.02	0.99	1.02	22.6	20.3	14.7	1.6	3.1
11.0	1.0	0.5	1.02	0.99	1.02	24.9	22.4	16.2	1.4	2.8
13.0	1.0	0.5	1.03	0.98	1.03	27.3	24.5	17.7	1.3	2.6
15.0	1.0	0.5	1.03	0.98	1.03	29.6	26.6	19.2	1.2	2.4
17.0	1.0	0.5	1.03	0.98	1.03	31.9	28.7	20.7	1.1	2.3
19.0	1.0	0.5	1.04	0.98	1.04	34.2	30.8	22.2	1.1	2.2
21.0	1.0	0.5	1.04	0.98	1.04	36.5	32.9	23.7	1.0	2.1

Note: Depth and inclination modifier were taken as 1 because the load is applied axially and during construction the soils above the footing are to be excavated.

Wall 05.85L-B Bearing Resistance (ESU 2B)



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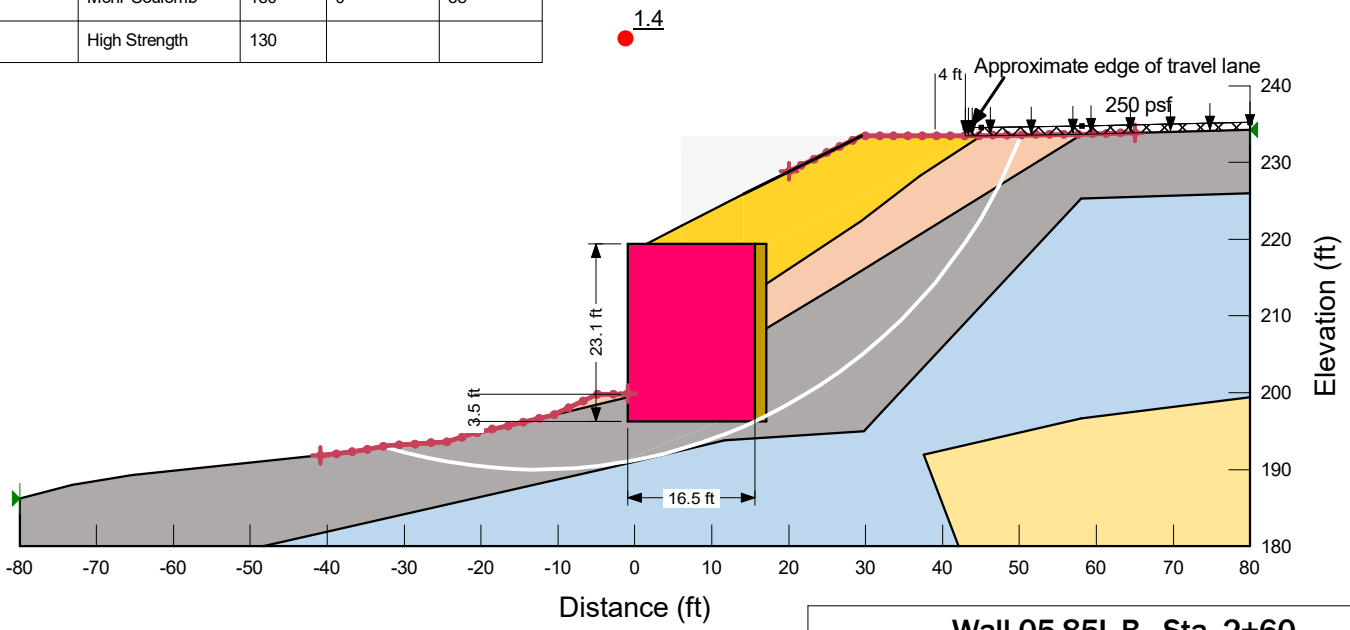
Earth Science + Technology

Shallow Foundation Design

Figure 1

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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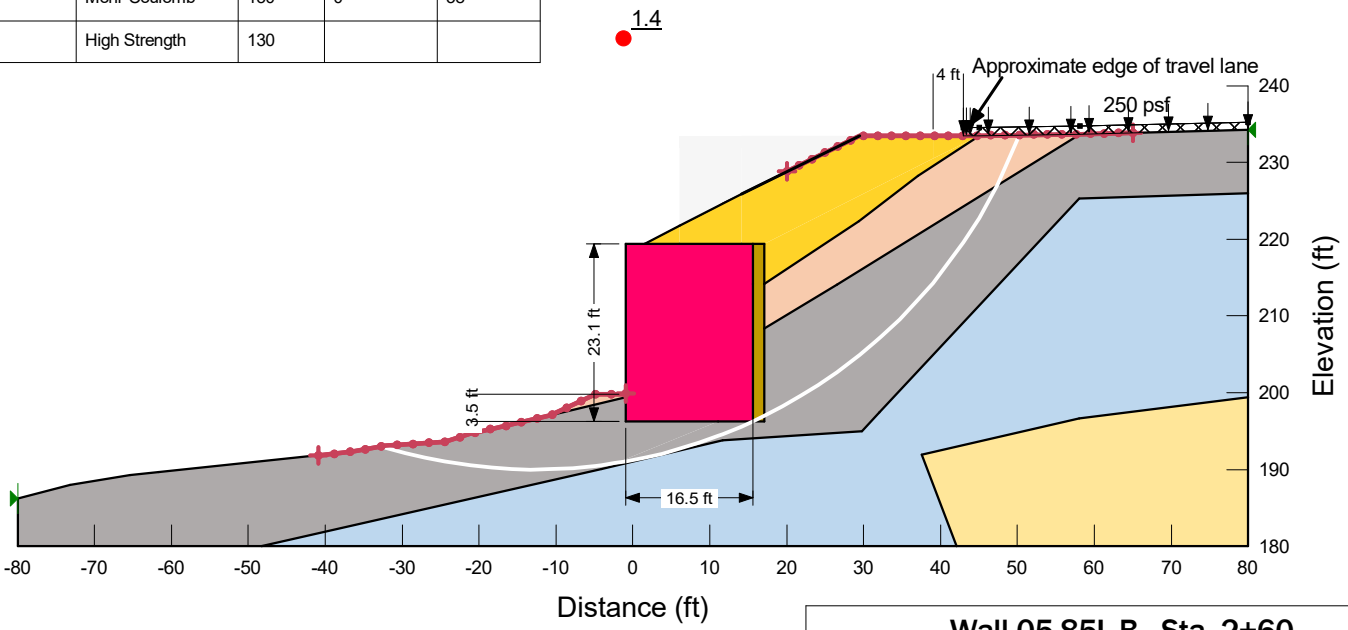
Wall 05.85L-B - Sta. 2+60
Static Global Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

00180-366-01 Date Exported: 01/14/22

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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Wall 05.85L-B - Sta. 2+60
Static Global Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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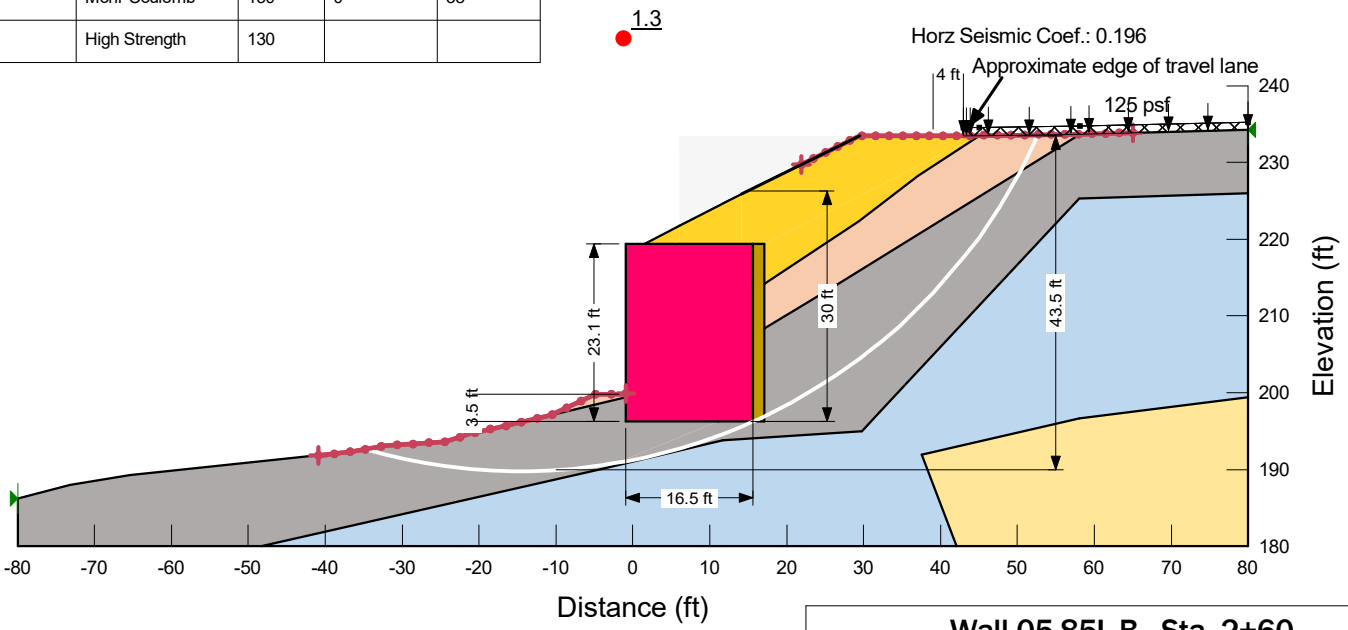
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	Mohr-Coulomb	130	100	41
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	115	200	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Global Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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00180-366-01 Date Exported: 01/14/22

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	Mohr-Coulomb	130	100	41
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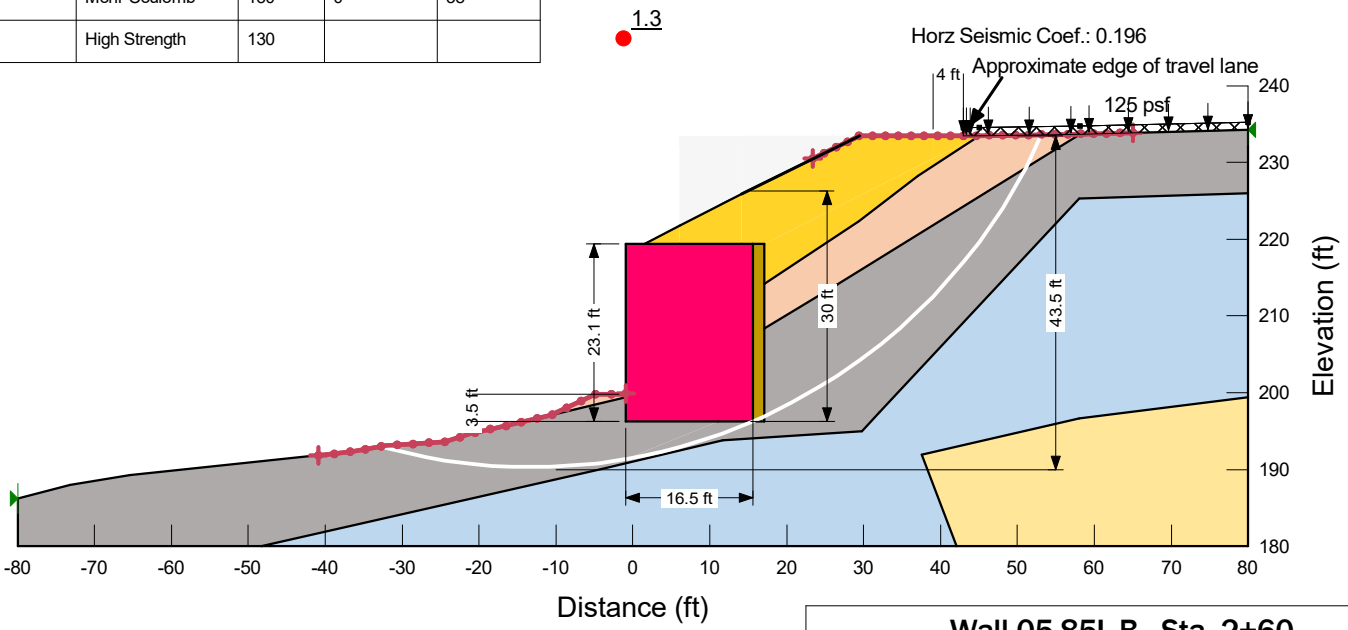
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38
	SEW Wall	High Strength	130		



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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Global Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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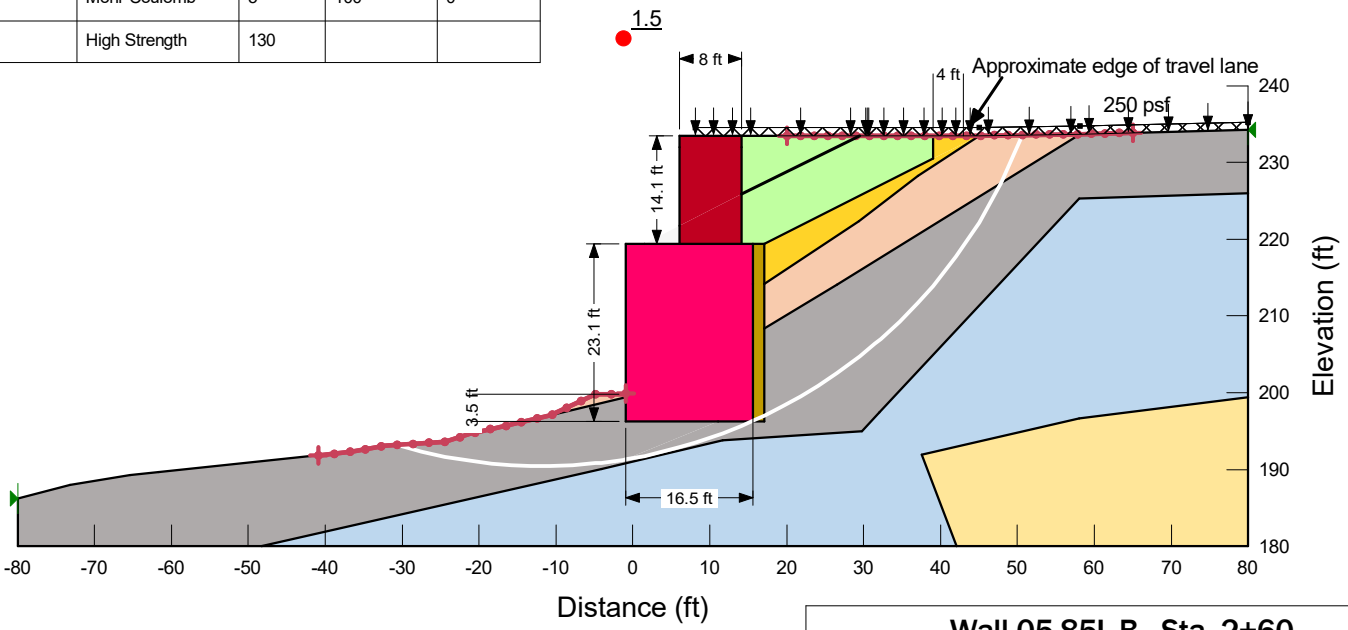
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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Wall 05.85L-B - Sta. 2+60
Static Global Stability+ FC Wall (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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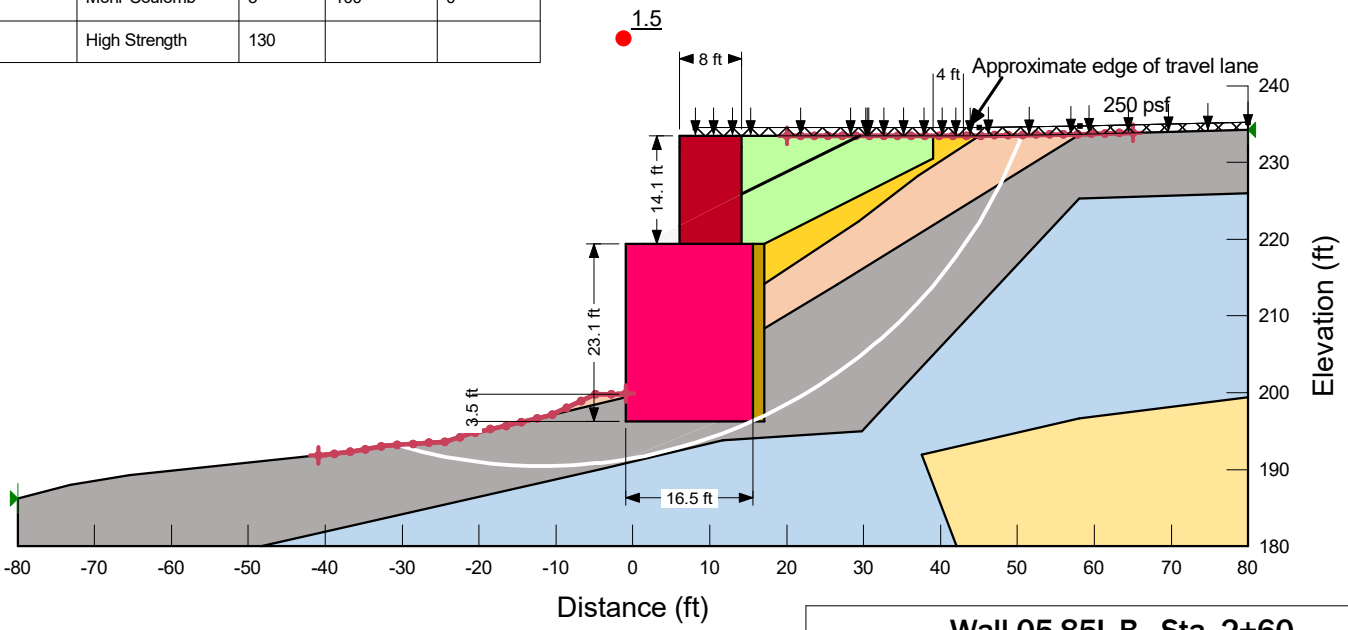
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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Wall 05.85L-B - Sta. 2+60
Static Global Stability + FC Wall (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
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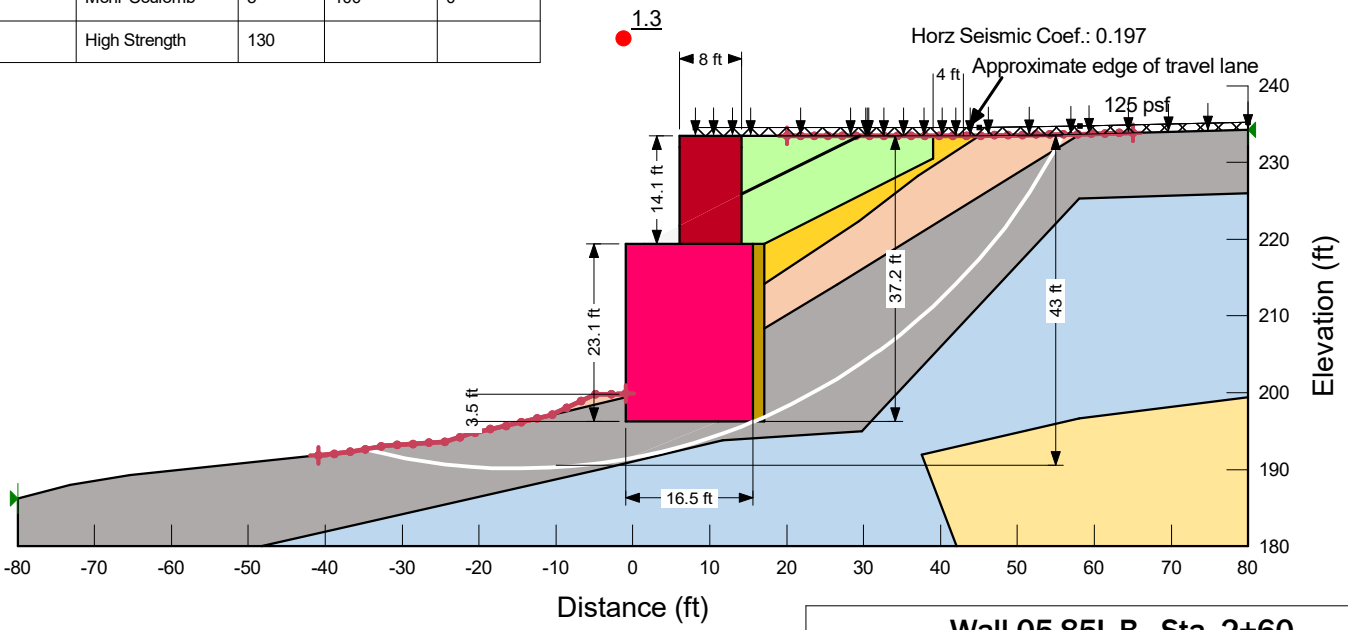
	Lightweight EPS	Mohr-Coulomb	5	100	0
	SEW Wall	High Strength	130		



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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Global Stability + FC Wall (S)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

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Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	Mohr-Coulomb	130	100	41
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	115	200	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
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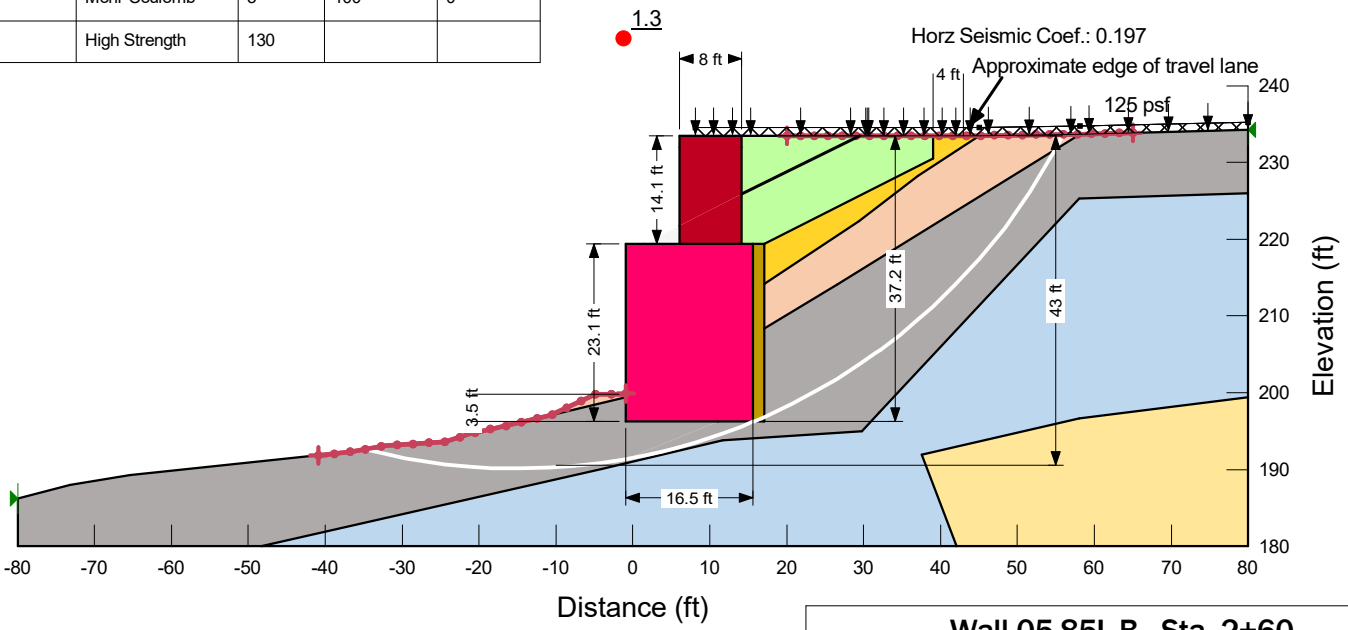

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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Global Stability + FC Wall (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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00180-366-01 Date Exported: 01/14/22

Calculating MSE Strip Properties for Slope/W (Wall 05.85L-B Sta. 2+60)

For global stability analyses, the MSE wall is modeled as a high strength material and the failure is forced outside of the reinforced zone. To check for compound stability, the high strength material is replaced with gravel borrow and reinforcing strips. The properties of the metal strips are calculated based on FHWA NHI-10-024 and NHI-10-025. The reinforcement properties are converted to per unit width basis, and implemented as a continous layer in Slope/W.

Input Soil Properties:

Backfill meeting WSDOT standard specifications 9-03.14(4), Gravel Borrow for Structural Earth Wall.

$\phi_{gravel} := 38\ \textit{deg}$

Input Strip Properties:

50mm wide and 4mm thick with Grade 65 steel.

$width := 2\ \textit{in}$

$thickness := \frac{5}{32}\ \textit{in}$ Gross thickness (no corrosion)

$f_y := 65.0\ \textit{ksi}$ Yield stress

Calculate Corrosion Reduction:

Calculate new cross-sectional area of steel straps after 75 years of corrosion exposure.

Category	Steel Thickness	Minimum Galvanization Thickness
Strip	< ¼ in. (6.4 mm)	3.4 mils (85 µm)
	> ¼ in. (6.4 mm)	3.9 mils (100 µm)
Wire*	All diameters	3.4 mils (85 µm)
* For bar mats fabricated from uncoated steel wire.		

The corrosion rates presented in Table 3-8 are suitable for conservative design. **These rates assume a moderately corrosive backfill material having the controlled electrochemical property limits** that are discussed under electrochemical properties in this chapter.

Table 3-8 Steel Corrosion Rates for Moderately Corrosive Reinforced Fill.

For zinc/side:	0.58 mils/yr (15 µm/year) (first 2 years)
	0.16 mils/yr (4 µm/year) (thereafter)
For residual carbon steel/side:	0.47 mils/yr (12 µm/year) (thereafter)

Calculate time (in years) to corrode through galvinization.

$0.58 \cdot 2 + 0.16 \cdot (t_g - 2) = 3.4$

$$t_g := \frac{3.4 - 0.58 \cdot 2}{0.16} + 2 = 16$$

$$t_{75\_years} := thickness - 0.47 \cdot 0.001 \ \frac{in}{yr} \cdot \left(75 - t_g\right) \ yr \cdot 2 = 0.101 \ in$$

$A_c := width \cdot t_{75\_years} = 0.202 \ in^2$ New cross-sectional area after 75 years of corrosion exposure

LRFD Resistance Factors for Tensile and Pullout Resistance for MSE Walls with Metal Straps:

Table 4-7. Resistance Factors, ϕ, for Tensile and Pullout Resistance for MSE Walls
(after Table 11.5.6-1, AASHTO {2007}).

Reinforcement Type and Loading Condition			Resistance Factor
Metallic reinforcement and connectors	Strip reinforcements (A)		
		Static loading	0.75
		Combined static/earthquake loading	1.00
		Combined static/traffic barrier impact (B)	1.00
	Grid reinforcements (A, C)		
		Static loading	0.65
		Combined static/earthquake loading	0.85
		Combined static/traffic barrier impact (B)	0.85
Geosynthetic reinforcement and connectors		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.20
Pullout resistance of tensile reinforcement (metallic and geosynthetic)		Static loading	0.90
		Combined static/earthquake loading	1.20
		Combined static/traffic barrier impact (B)	1.00

Notes:
A. Apply to gross cross-section less sacrificial area. For sections with holes, reduce gross area in accordance with AASHTO (2007) Article 6.8.3 and apply to net section less sacrificial area.
B. Combined static/traffic barrier impact resistance factors are not presented in AASHTO.
C. Applies to grid reinforcements connected to rigid facing element, e.g., a concrete panel or block. For grid reinforcements connected to a flexible facing mat or which are continuous with the facing mat, use the resistance factor for strip reinforcements.

$\Phi_{static} := 0.75$ $\Phi_{pullout\_static} := 0.9$

$\Phi_{seismic} := 1.0$ $\Phi_{pullout\_seismic} := 1.2$

Calculate Slope/W Reinforcement Inputs:

$H_{wall} := 23.1\ ft$

Assuming strip layout based on typical RECO A panel, the vertical (s_v) and the horizontal (s_h) spacing of the steel straps within each SE wall panel was determined. For calculation efficiency, the calculations are performed using matrices.

$$s_v := \begin{bmatrix} 0.5 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \\ 2.4 \end{bmatrix} ft \qquad s_h := \begin{bmatrix} 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \\ 2.5 \end{bmatrix} ft$$

The matrix respresents the same order of the SE Wall reinforcement. Top row of the matrix represents the bottom row of the SE Wall reinforcement and the bottom row of the matrix represents the row of reinforcement closest to the ground surface.

$i := 0 .. \text{length}(s_v) - 1$

Calculate number of elements

$$elevation_i := \sum_{j=0}^{i} s_{v_j} = \begin{bmatrix} 0.5 \\ 2.9 \\ 5.3 \\ 7.7 \\ 10.1 \\ 12.5 \\ 14.9 \\ 17.3 \\ 19.7 \\ 22.1 \end{bmatrix} ft$$

Calculate each strap's vertical elevation, with the base of the wall as elevation 0 ft. Top row of the matrix represents the bottom reinforcement row.

$$depth_i := H_{wall} - elevation_i = \begin{bmatrix} 22.6 \\ 20.2 \\ 17.8 \\ 15.4 \\ 13 \\ 10.6 \\ 8.2 \\ 5.8 \\ 3.4 \\ 1 \end{bmatrix} ft$$

Calculate each strap's depth from the ground surface.

Calculate Pullout Resistance Slope/W Input:

For design and comparison purposes, a normalized definition of pullout resistance will be used throughout the manual. The pullout resistance, P_r, at each of the reinforcement levels per unit width of reinforcement is given by:

$$P_r = F^* \alpha \sigma_v' L_e C \qquad (3\text{-}2)$$

where:

- $L_e C$ = the total surface area per unit width of the reinforcement in the resistive zone behind the failure surface
- L_e = the embedment or adherence length in the resisting zone behind the failure surface
- C = the reinforcement effective unit perimeter; e.g., C = 2 for and sheets, and because the edges are neglected C = 2 for strips and grids
- F^* = the pullout resistance (or friction-bearing-interaction) factor
- α = a scale effect correction factor to account for a non linear stress reduction over the embedded length of highly extensible reinforcements, based on laboratory data (generally 1.0 for metallic reinforcements and 0.6 to 1.0 for geosynthetic reinforcements, see Table 3-6).
- σ'_v = the effective vertical stress at the soil-reinforcement interfaces.

The factored pullout resistance per unit width of the wall is then given by:

$$P_r = \Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) \cdot \frac{width}{s_h}$$

In Slope/W, pullout resistance per unit width of wall is given by:

$$P_r = \left(c + \sigma_v' \cdot tan\left(\phi_{interface}\right)\right) \cdot \alpha \cdot L_e \cdot C$$

Where α and C can be defined within the reinforcement properties, and are set to be the same as defined above. Overburden pressure, σ_v' and effective length, Le are determined from the limit equilibrium analysis performed in Slope/W. Interface adhesion, c, is assumed to be negligable for metal straps in granular backfill.

To select a representative $\phi_{interface}$ that will produce the same factored resistance per unit width of wall, the two expressions are set to be equal:

$$\Phi_{pullout} \left(F \cdot \alpha \cdot \sigma_v' \cdot L_e \cdot C\right) \cdot \frac{width}{s_h} = \sigma_v' \cdot tan\left(\phi_{interface}\right) \cdot \alpha \cdot L_e \cdot C$$

Removing common constants and rearranging produces:

$$\phi_{interface} = atan\left(\frac{\Phi_{pullout} \cdot F \cdot width}{s_h}\right)$$

Calculate Pullout Resistance Factor F*:

In the absence of site-specific pullout testing data, it is reasonable to use the semi-empirical relationships described in the following paragraphs in conjunction with the standard specifications for reinforced fill to provide a conservative evaluation of pullout resistance.

For steel ribbed reinforcement, the Pullout Resistance Factor F* is commonly taken as:

$$F^* = \tan\rho = 1.2 + \log C_u \text{ at the top of the structure} = 2.0 \text{ maximum} \quad (3\text{-}4)$$

$$F^* = \tan\phi \text{ at a depth of 20 ft (6 m) and below} \quad (3\text{-}5)$$

where C_u is the uniformity coefficient of the backfill (D_{60}/D_{10}). **If the specific C_u for the wall backfill is unknown at design time, a $C_u = 4$ should be assumed (i.e., $F^* = 1.8$ at the top of the wall) for reinforced fills meeting the requirements of Section 3.1 of this chapter.**

$C_u := 6.3$ Backfill used will need to meet gradation assumed

$F_{max} := 1.2 + \log(C_u) = 1.999$

$$F_i := \begin{cases} \text{if } depth_i < 20\ ft \\ \quad (F_{max} - \tan(\phi_{gravel})) \cdot \left(\frac{(20\ ft - depth_i)}{20\ ft}\right) + \tan(\phi_{gravel}) \\ \text{else} \\ \quad \tan(\phi_{gravel}) \end{cases}$$

$$F = \begin{bmatrix} 0.78 \\ 0.78 \\ 0.92 \\ 1.06 \\ 1.21 \\ 1.35 \\ 1.5 \\ 1.65 \\ 1.79 \\ 1.94 \end{bmatrix}$$

Calculated F* for each row of reinforcement.
Top row of matrix represents the bottom row of reinforcement.

Calculate Interface Shear Angle (degrees):

$$\phi_{interface\_static} := \operatorname{atan}\left(\frac{\Phi_{pullout\_static} \cdot F \cdot width}{s_h}\right) = \begin{bmatrix} 2.7 \\ 2.7 \\ 3.1 \\ 3.6 \\ 4.1 \\ 4.6 \\ 5.1 \\ 5.6 \\ 6.1 \\ 6.6 \end{bmatrix} \ deg$$

Static interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

$$\phi_{interface\_seismic} := \operatorname{atan}\left(\frac{\Phi_{pullout\_seismic} \cdot F \cdot width}{s_h}\right) = \begin{bmatrix} 3.6 \\ 3.6 \\ 4.2 \\ 4.9 \\ 5.5 \\ 6.2 \\ 6.8 \\ 7.5 \\ 8.2 \\ 8.8 \end{bmatrix} \ deg$$

Seismic interface shear angle for each row of reinforcement. Top row of matrix represents the bottom reinforcement row.

Calculate Allowable Tensile Capacity of Steel Straps:

$$T_{al\_static} := \Phi_{static} \cdot f_y \ A_c = 9.83 \ kip$$

$$T_{al\_seismic} := \Phi_{seismic} \cdot f_y \ A_c = 13.1 \ kip$$

Slope/W does not have strap reinforcement inputs. Therefore, the tensile strength of the straps were modeled as continuous reinforcement. The calculated allowable tensile strap capacity was converted to a continuous reinforcement tensile capcity by distributing the capacity over the tributary width.

$$T_{al\_static\_row} := \frac{T_{al\_static}}{s_h} = \begin{bmatrix} 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \\ 3.93 \end{bmatrix} \ \frac{kip}{ft}$$

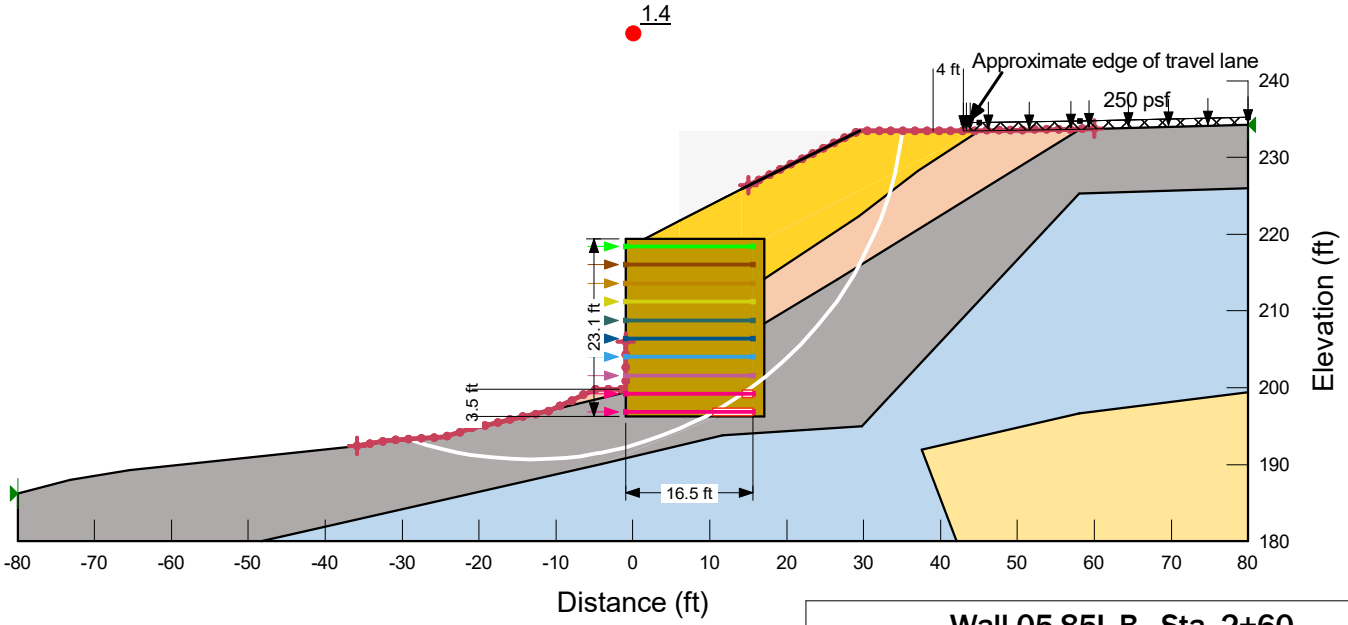
Static tensile capacity Slope/W inputs for each wall reinforcement row. Top row of the matrix represents the bottowm row of the SE Wall reinforcement.

$$T_{al\_seismic\_row} := \frac{T_{al\_seismic}}{s_h} = \begin{bmatrix} 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \\ 5.24 \end{bmatrix} \frac{kip}{ft}$$

Seismic tensile capacity Slope/W inputs for each wall reinforcement row. Top row of the matrix represents the bottowm row of the SE Wall reinforcement.

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (2 strips)	6.6	3,930
	Row 2 (2 strips)	6.1	3,930
	Row 3 (2 strips)	5.6	3,930
	Row 4 (2 strips)	5.1	3,930
	Row 5 (2 strips)	4.6	3,930
	Row 6 (2 strips)	4.1	3,930
	Row 7 (2 strips)	3.6	3,930
	Row 8 (2 strips)	3.1	3,930
	Row 9+ (2 strips)	2.7	3,930



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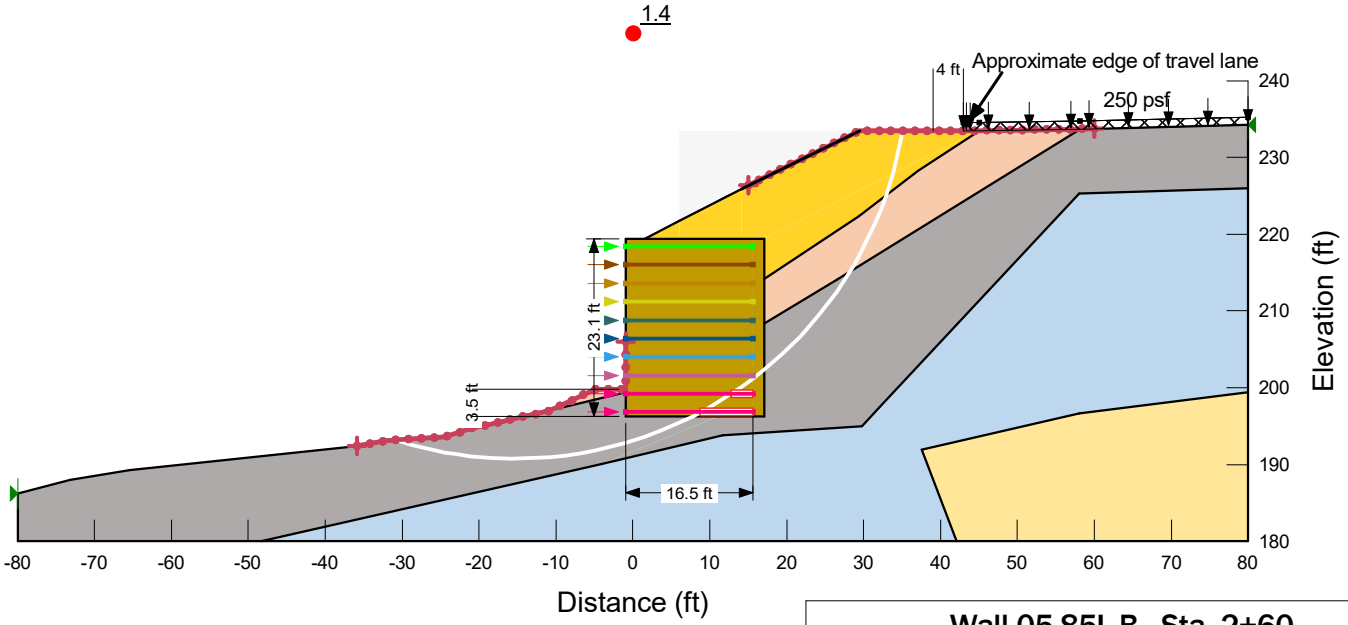
Wall 05.85L-B - Sta. 2+60
Static Compound Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (2 strips)	6.6	3,930
	Row 2 (2 strips)	6.1	3,930
	Row 3 (2 strips)	5.6	3,930
	Row 4 (2 strips)	5.1	3,930
	Row 5 (2 strips)	4.6	3,930
	Row 6 (2 strips)	4.1	3,930
	Row 7 (2 strips)	3.6	3,930
	Row 8 (2 strips)	3.1	3,930
	Row 9+ (2 strips)	2.7	3,930



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Wall 05.85L-B - Sta. 2+60
Static Compound Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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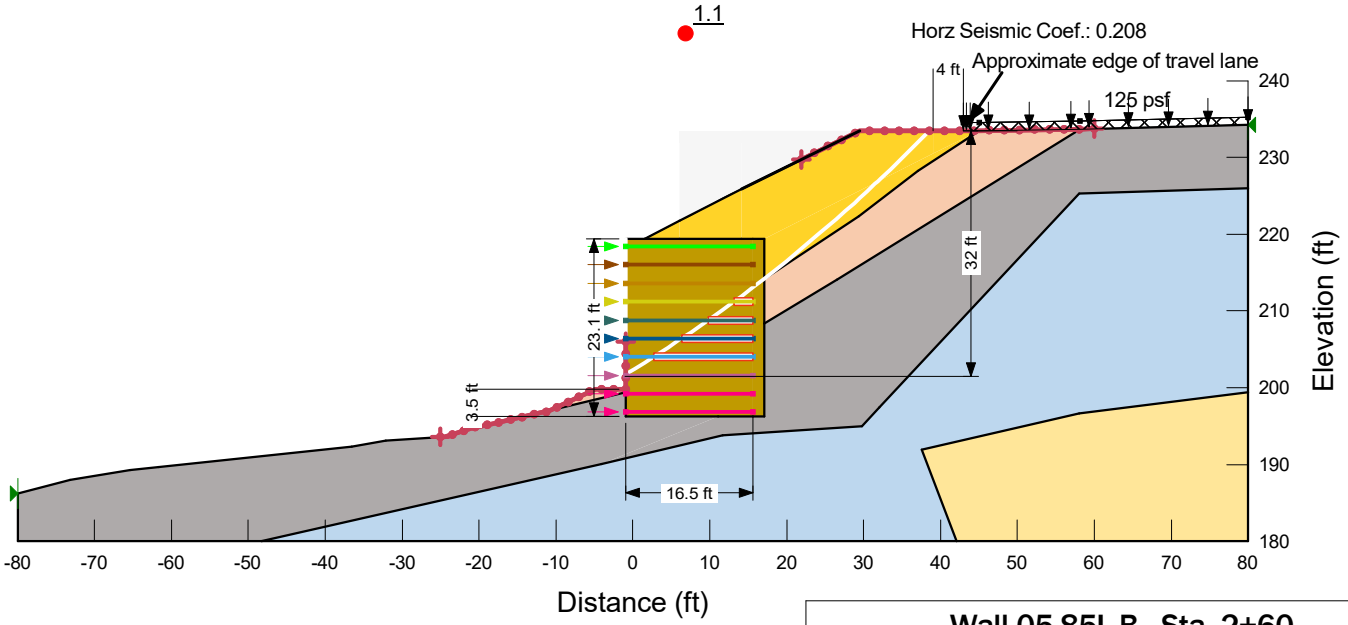
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	Mohr-Coulomb	130	100	41
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	115	200	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (2 strips)(EQ)	8.8	5,240
	Row 2 (2 strips)(EQ)	8.2	5,240
	Row 3 (2 strips)(EQ)	7.5	5,240
	Row 4 (2 strips)(EQ)	6.8	5,240
	Row 5 (2 strips)(EQ)	6.2	5,240
	Row 6 (2 strips)(EQ)	5.5	5,240
	Row 7 (2 strips)(EQ)	4.9	5,240
	Row 8 (2 strips)(EQ)	4.2	5,240
	Row 9+ (2 strips)(EQ)	3.6	5,240



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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Compound Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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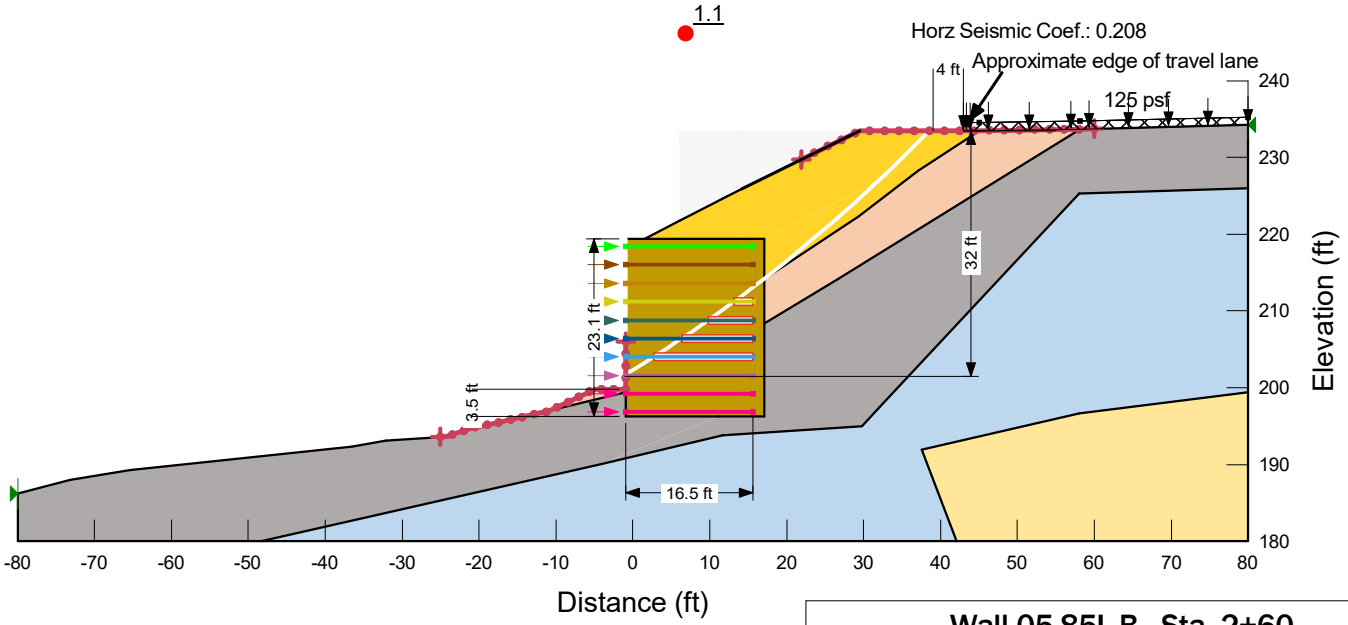
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	Mohr-Coulomb	130	100	41
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	115	200	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Gravel Borrow	Mohr-Coulomb	130	0	38

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (2 strips)(EQ)	8.8	5,240
	Row 2 (2 strips)(EQ)	8.2	5,240
	Row 3 (2 strips)(EQ)	7.5	5,240
	Row 4 (2 strips)(EQ)	6.8	5,240
	Row 5 (2 strips)(EQ)	6.2	5,240
	Row 6 (2 strips)(EQ)	5.5	5,240
	Row 7 (2 strips)(EQ)	4.9	5,240
	Row 8 (2 strips)(EQ)	4.2	5,240
	Row 9+ (2 strips)(EQ)	3.6	5,240



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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Compound Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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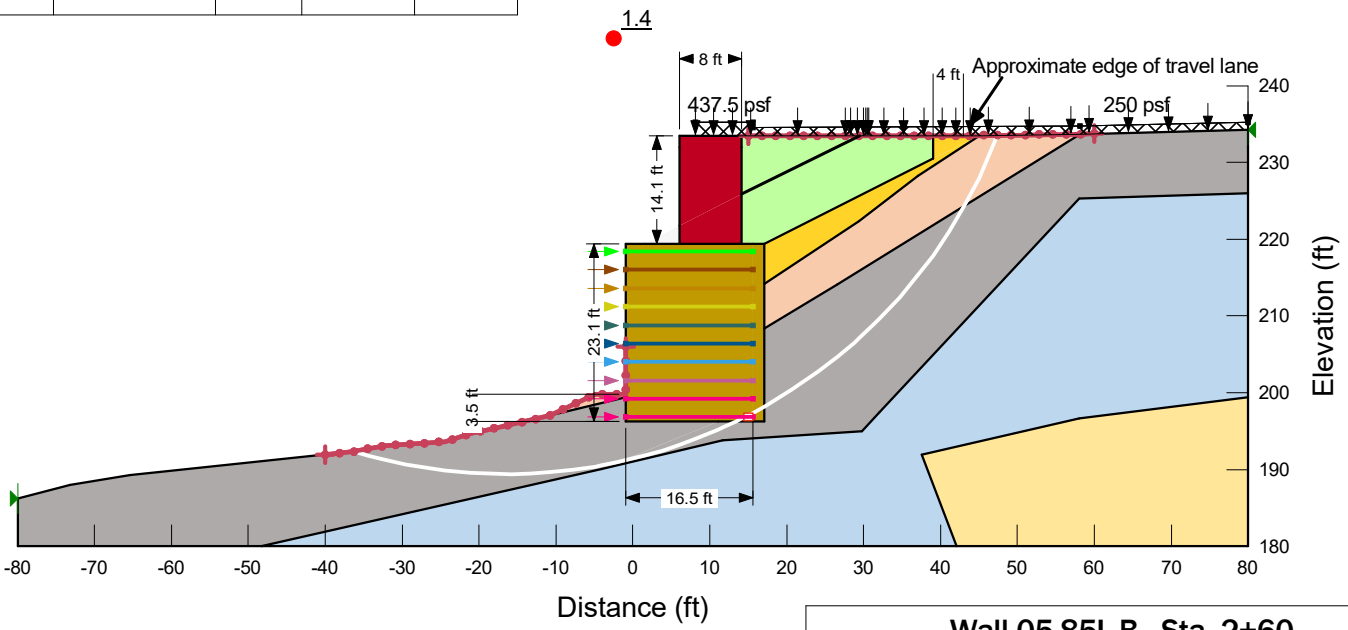
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (2 strips)	6.6	3,930
	Row 2 (2 strips)	6.1	3,930
	Row 3 (2 strips)	5.6	3,930
	Row 4 (2 strips)	5.1	3,930
	Row 5 (2 strips)	4.6	3,930
	Row 6 (2 strips)	4.1	3,930
	Row 7 (2 strips)	3.6	3,930
	Row 8 (2 strips)	3.1	3,930
	Row 9+ (2 strips)	2.7	3,930



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Wall 05.85L-B - Sta. 2+60
Static Compound Stability + FC Wall (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	Mohr-Coulomb	130	0	41
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	115	0	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

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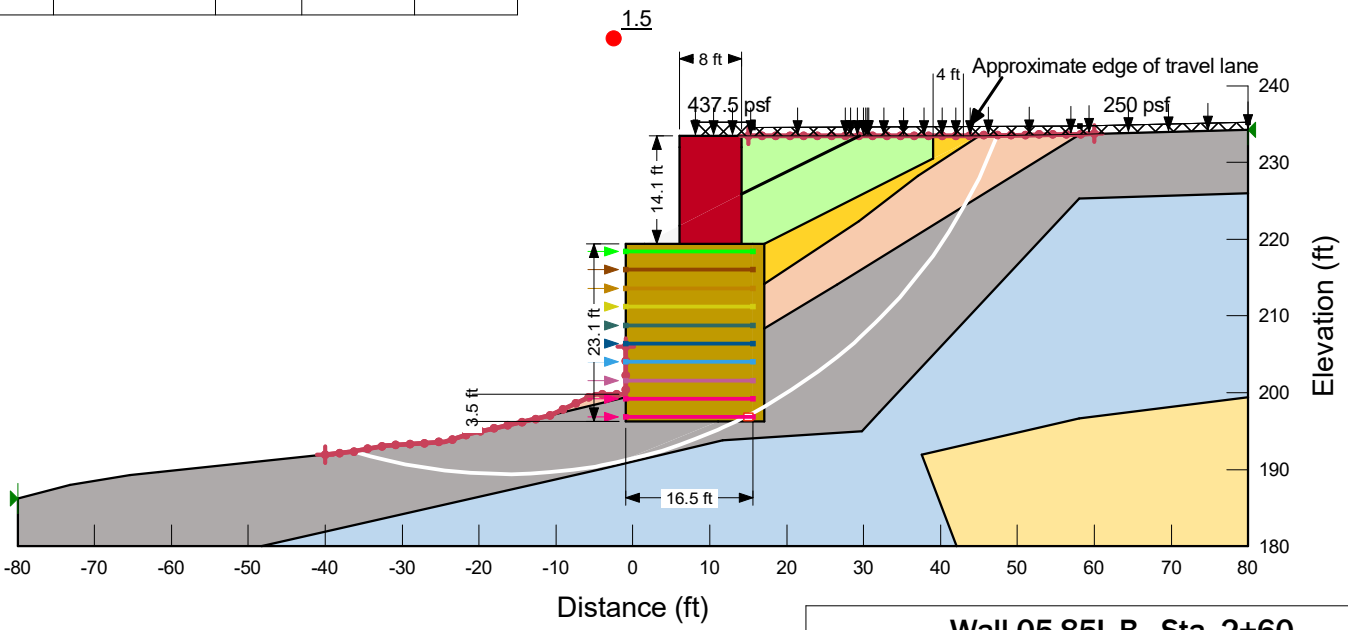
	Row 3 (2 strips)	5.6	3,930
	Row 4 (2 strips)	5.1	3,930
	Row 5 (2 strips)	4.6	3,930
	Row 6 (2 strips)	4.1	3,930
	Row 7 (2 strips)	3.6	3,930
	Row 8 (2 strips)	3.1	3,930
	Row 9+ (2 strips)	2.7	3,930



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Wall 05.85L-B - Sta. 2+60
Static Compound Stability + FC Wall (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	Mohr-Coulomb	130	100	41
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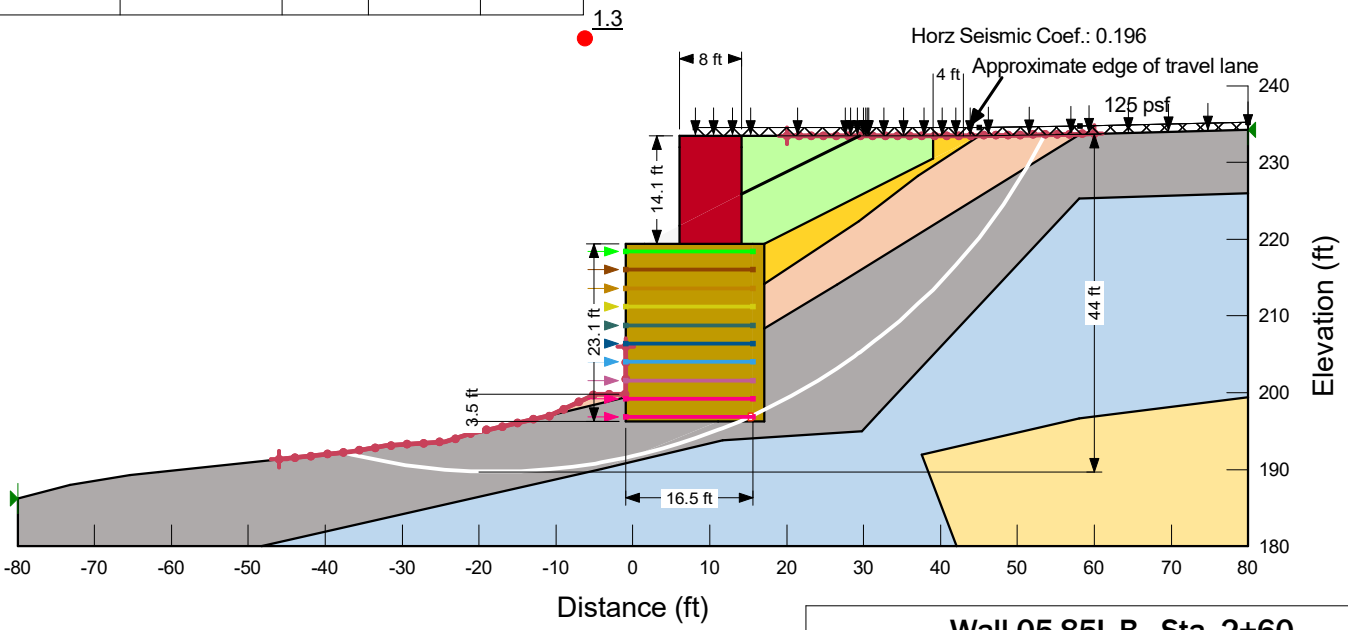
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (2 strips)(EQ)	8.8	5,240
	Row 2 (2 strips)(EQ)	8.2	5,240
	Row 3 (2 strips)(EQ)	7.5	5,240
	Row 4 (2 strips)(EQ)	6.8	5,240
	Row 5 (2 strips)(EQ)	6.2	5,240
	Row 6 (2 strips)(EQ)	5.5	5,240
	Row 7 (2 strips)(EQ)	4.9	5,240
	Row 8 (2 strips)(EQ)	4.2	5,240
	Row 9+ (2 strips)(EQ)	3.6	5,240



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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Compound Stability + FC Wall (S)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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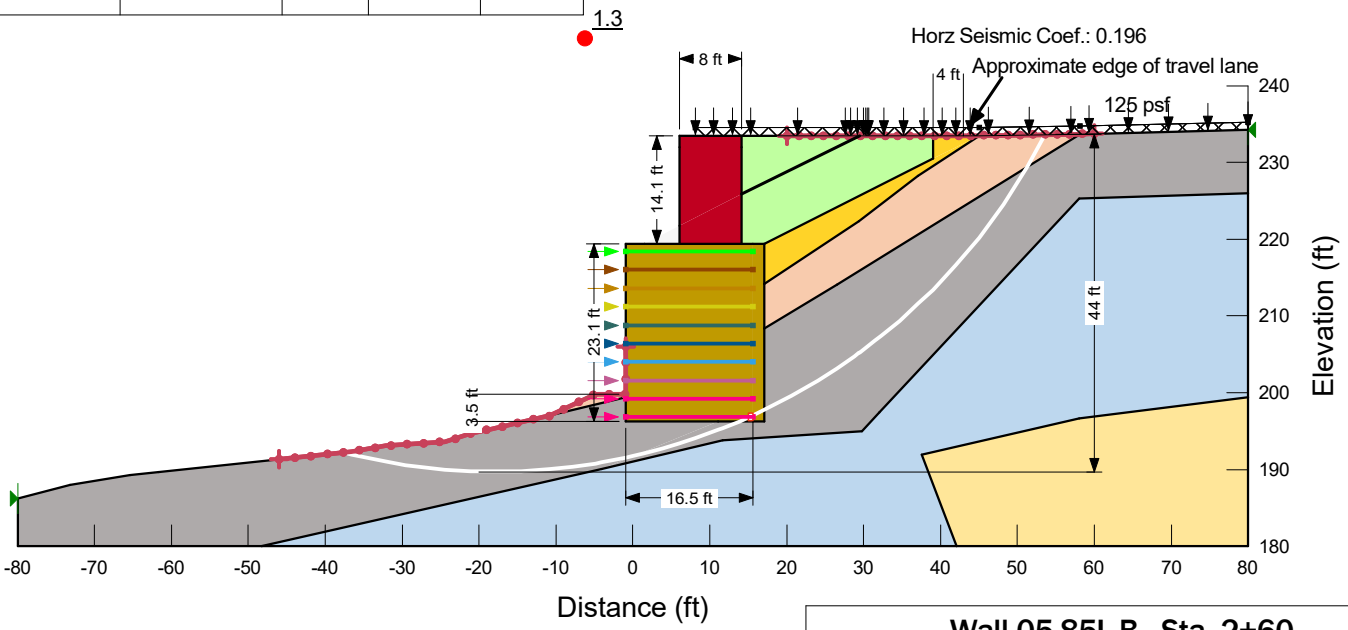
Color	Name	Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow (Apparent Cohesion)	Mohr-Coulomb	120	50	32
	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	Mohr-Coulomb	130	100	41
	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	Mohr-Coulomb	115	200	34
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	42
	Forward Compatible Wall	High Strength	130		
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Lightweight EPS	Mohr-Coulomb	5	100	0

Color	Name	Interface Shear Angle (°)	Tensile Capacity (lbf)
	Row 1 (2 strips)(EQ)	8.8	5,240
	Row 2 (2 strips)(EQ)	8.2	5,240
	Row 3 (2 strips)(EQ)	7.5	5,240
	Row 4 (2 strips)(EQ)	6.8	5,240
	Row 5 (2 strips)(EQ)	6.2	5,240
	Row 6 (2 strips)(EQ)	5.5	5,240
	Row 7 (2 strips)(EQ)	4.9	5,240
	Row 8 (2 strips)(EQ)	4.2	5,240
	Row 9+ (2 strips)(EQ)	3.6	5,240



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Wall 05.85L-B - Sta. 2+60
Pseudo-Static Global Stability + FC Wall (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

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Appendix G
Embankment EMB: I-405 SB MP 5.97 TO 5.83 Calculations

APPENDIX G – EMBANKMENT EMB: I-405 SB MP 5.97 TO 5.83 CALCULATIONS

General

This appendix presents geotechnical calculations for embankment EMB: I-405 SB MP 5.97 to 5.83 including:

- ESU Soil Properties
- Seismic Hazard Analysis
- Elastic Settlement
- Global Stability

ESU Soil Properties

Design soil properties developed for Wall 05.85L-A were used for embankment EMB: I-405 SB MP 5.97 to 5.83. A detailed description of the soil property development is presented in Section 7.1 of this geotechnical engineering report. Supporting calculations are provided in Appendix E. Supporting calculations for the development of elastic moduli used for the embankment elastic settlement analysis are presented in this appendix

Seismic Hazard Analysis

The representative site class, design seismic parameters, the mean earthquake magnitude, and liquefaction potential developed for Wall 05.85L-A were used for embankment EMB: I-405 SB MP 5.97 TO 5.83. Detailed descriptions of our seismic hazard analysis methodology and the results are presented in Section 7.2 and Section 8.1, respectively, of this report. Supporting calculations are provided in Appendix E.

Elastic Settlement

We estimated the static elastic settlement for the placement of new fill (common borrow) on the embankment using the computer design software Settle3 (Rocscience 2021). We modeled the applied fill load along the approximate length of the embankment and the fill slope at the design section. We used the elastic moduli of the ESUs beneath the new fill in the embankment to evaluate immediate settlement of the embankment.

Detailed descriptions of our elastic settlement methodology and the results of our analyses are presented in Section 7.5 and Section 8.4, respectively, of this report. Supporting calculations are provided in this appendix. Settle3 output reports are provided in Appendix H.

Global Stability

We performed global stability analyses for the following critical design section:

- EMB I-405 SB MP 5.88 – Center of embankment

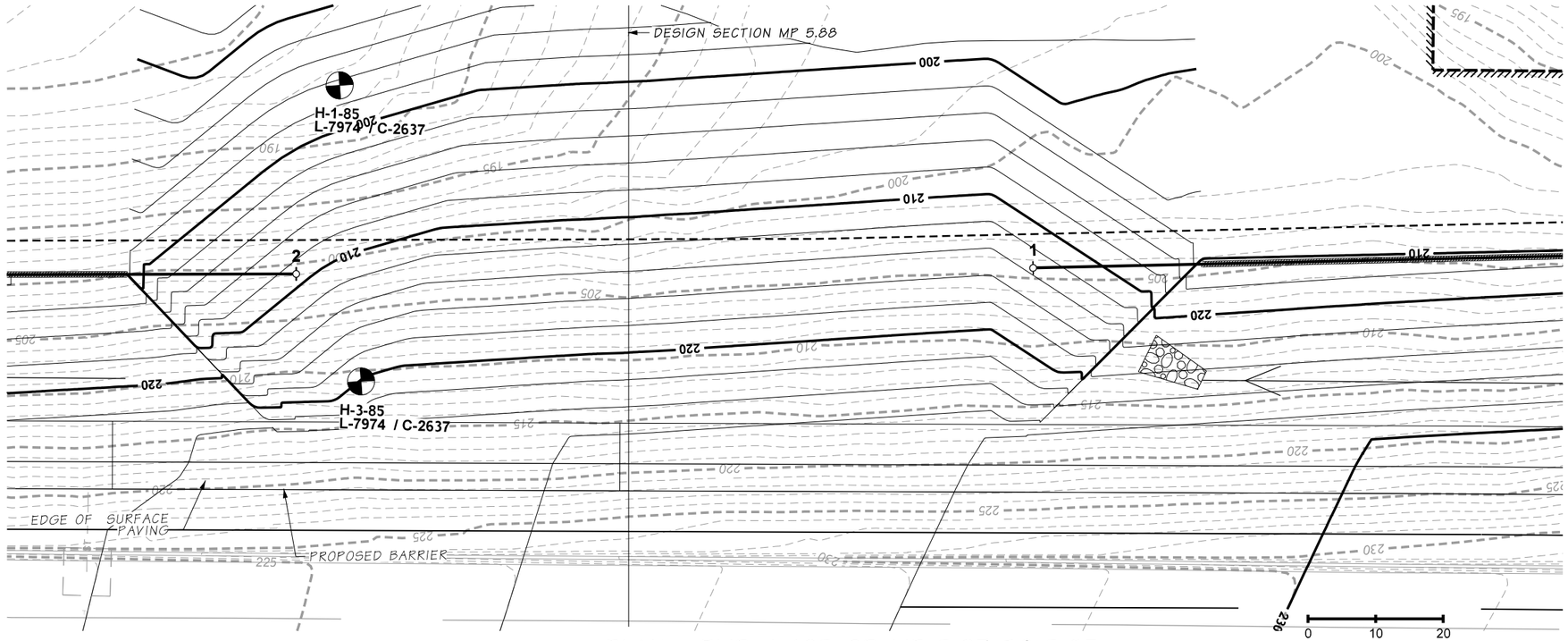
Global stability was evaluated using limit equilibrium analysis methodology outlined in the Project GDM using the computer design software Slope/W (Geo Slope International, Ltd. 2020). We analyzed FSs using Spencer's method and Morgenstern-Price for a circular failure surface.

A traffic surcharge of 250 psf was applied at the top of the embankment for the static global stability analysis.

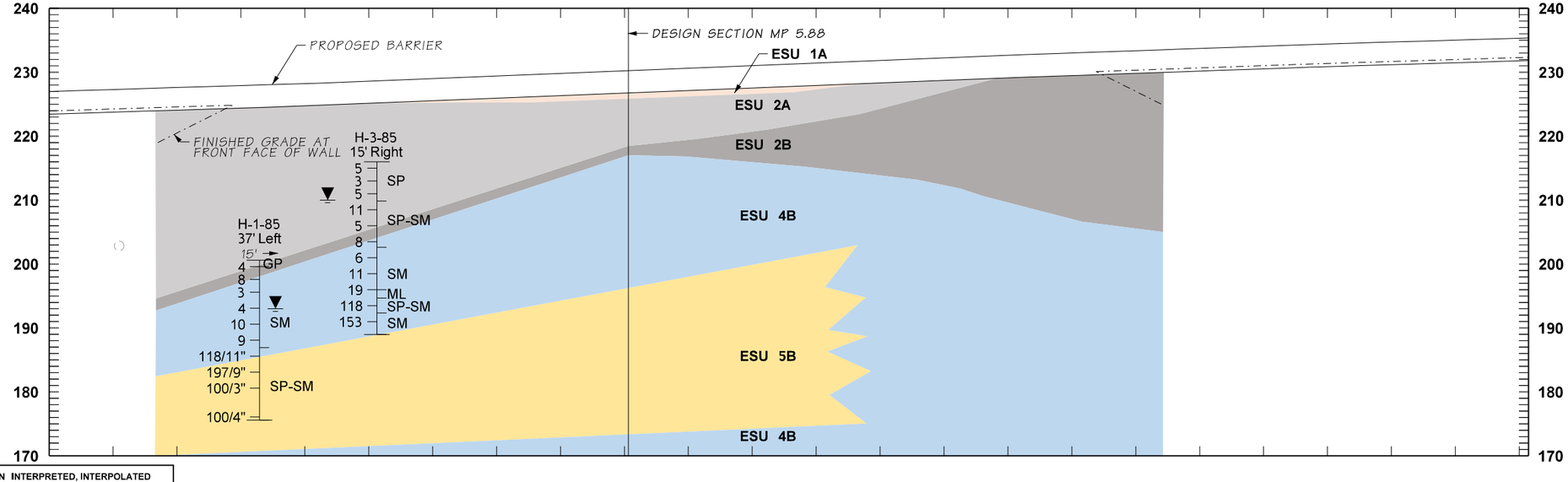
The groundwater level was modeled using results from the seepage analysis at Wall 05.85L-A. Steady-state seepage results are presented in Appendix E.

Detailed descriptions of our global stability analysis methodology and the results of our analyses are presented in Section 7.8 and Section 8.6, respectively, of this report. Global stability models showing FS for critical failures at the design section are provided in this appendix. Slope/W reports are provided in Appendix J.

Appendix G.1 - Embankment
EMB: I-405 SB MP 5.97 to 5.83
Plan, Profile and Sections



PLAN - EMB: I-405 SB MP 5.97 TO 5.83



SUBSURFACE PROFILE

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES. THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

FILE NAME	c:\users\tbyrd\documents\projectwise\workingdir\wsdot\dms16995\XL5467_EMB I-405 SB_PP.dgn				REGION NO.	STATE	FED.AID PROJ.NO.
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DATE	4/12/2021				JOB NUMBER		
PLOTTED BY	tbyrd						
DESIGNED BY					CONTRACT NO.		LOCATION NO.
ENTERED BY							
CHECKED BY							
PROJ. ENGR.							
REGIONAL ADM.		REVISION	DATE	BY			

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

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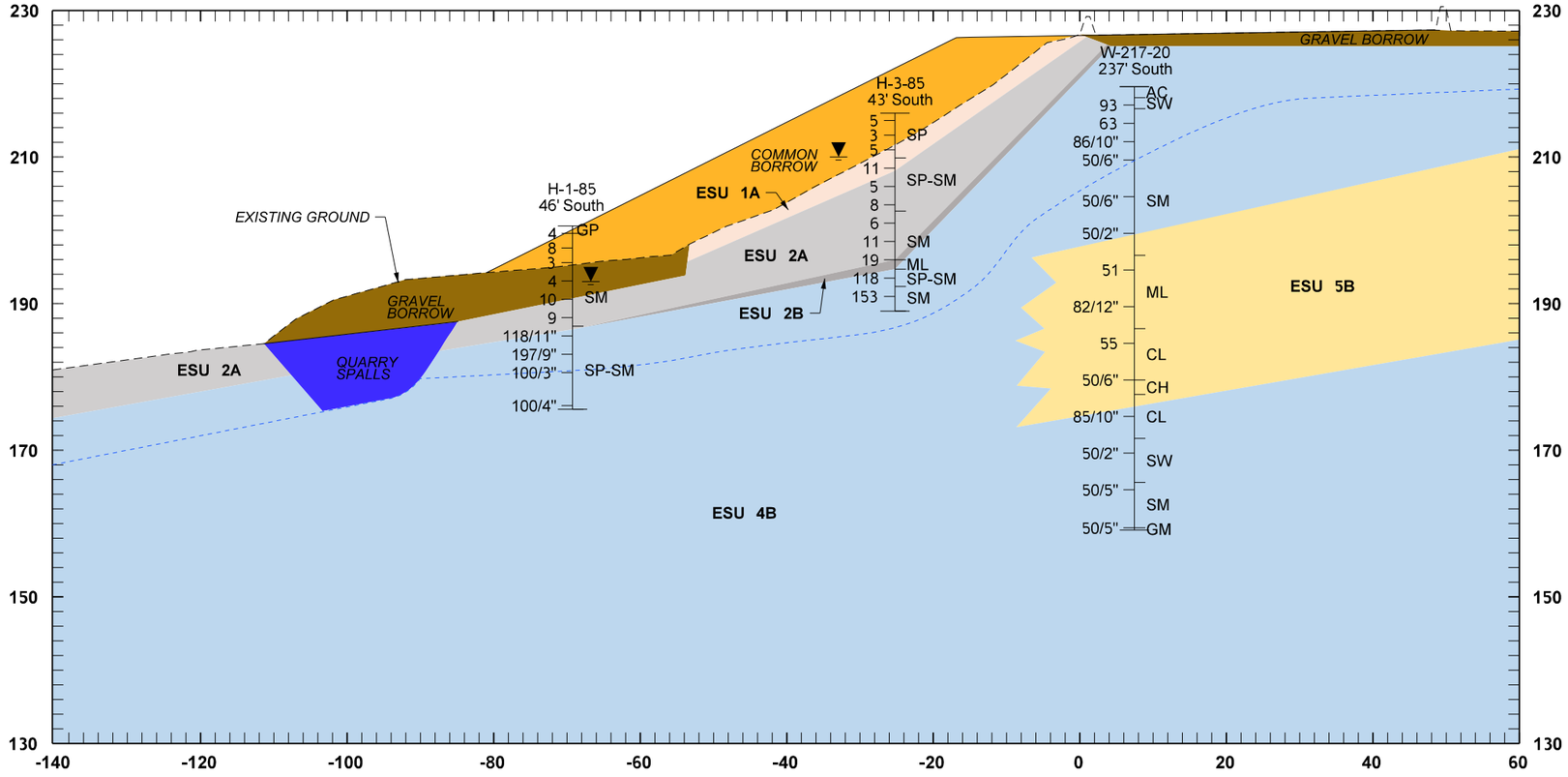
wood.

I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

EMBANKMENT PLAN AND PROFILE
EMB: I-405 SB MP 5.97 TO 5.83

PLAN REF NO

SHEET 1 OF 1 SHEETS



EMB: I-405 SB MP 5.88

THE ESU STRATIFICATION HAVE BEEN INTERPRETED, INTERPOLATED BETWEEN EXPLORATIONS, AND EXTRAPOLATED BEYOND EXPLORATIONS FOR ENGINEERING DESIGN PURPOSES, THE STRATA MAY NOT REPRESENT ACTUAL SUBSURFACE CONDITIONS. SEE THE EXPLORATION LOGS FOR DETAILED SUBSURFACE CONDITIONS AT THE LOCATION EXPLORED.

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DATE	4/20/2021						
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DESIGNED BY							
ENTERED BY							
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PROJ. ENGR.							
REGIONAL ADM.		REVISION	DATE	BY			

P.E. STAMP BOX — DATE

P.E. STAMP BOX — DATE

Washington State Department of Transportation

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I-405; RENTON TO BELLEVUE WIDENING AND EXPRESS TOLL LANES PROJECT

EMB: I-405 SB MP 5.88
DESIGN SECTION

PLAN REF NO

SHEET 1 OF 1 SHEETS

Appendix G.2 - Embankment EMB: I-405 SB MP 5.97 to 5.83 ESU Soil Property Calculations

(See Wall 05.85L-A Appendix E.2

for Complete ESU Soil Property Calculations)

The coefficient of consolidation, c_v, should be determined from the results of one-dimensional consolidation tests. The variability in laboratory determination of c_v results should be considered in the final selection of the value of c_v to be used for design.

Where evaluation of elastic settlement is critical to the design of the foundation or selection of the foundation type, in-situ methods such as PMT or *DMT* for evaluating the modulus of the stratum should be used.

A profile of σ_p', or OCR = σ_p'/σ_o', with depth should be developed for the site for design applications where the stress history could have a significant impact on the design properties selected and the performance of the foundation. As with consolidation properties, an upper and lower bound profile should be developed based on laboratory tests and plotted with a profile based on particular in-situ test(s), if used. It is particularly important to accurately compute preconsolidation stress values for relatively shallow depths where in-situ effective stresses are low. An underestimation of the preconsolidation stress at shallow depths will result in overly conservative estimates of settlement for shallow soil layers.

Due to the numerous simplifying assumptions associated with conventional consolidation theory, on which the coefficient of consolidation is based, it is unlikely that even the best estimates of c_v from high-quality laboratory tests will result in predictions of time rate of settlement in the field that are significantly better than a prediction within one order of magnitude. In general, the in-situ value of c_v is larger than the value measured in the laboratory test. Therefore, a rational approach is to select average, upper, and lower bound values for the appropriate stress range of concern for the design application. These values should be compared to values obtained from previous work performed in the same soil deposit. Under the best-case conditions, these values should be compared to values computed from measurements of excess pore pressures or settlement rates during construction of other structures.

CPTu tests in which the pore pressure dissipation rate is measured may be used to estimate the field coefficient of consolidation.

For preliminary analyses or where accurate prediction of settlement is not critical, values obtained from correlations to index properties presented in Sabatini et al. (2002) may be used.

For preliminary design or for final design where the prediction of deformation is not critical to structure performance, i.e., the structure design can tolerate the potential inaccuracies inherent in the correlations. The elastic properties (E_s, ν) of a soil may be estimated from empirical relationships presented in Table C10.4.6.3-1.

The specific definition of E_s is not always consistent for the various correlations and methods of in-situ measurement. See Sabatini et al. (2002) for additional details regarding the definition and determination of E_s.

An alternative method of evaluating the equivalent elastic modulus using measured shear wave velocities is presented in Sabatini et al. (2002).

Table C10.4.6.3-1—Elastic Constants of Various Soils (modified after U.S. Department of the Navy, 1982; Bowles, 1988)

Soil Type	Typical Range of Young's Modulus Values, E_s (ksi)	Poisson's Ratio, ν (dim)
Clay:		
Soft sensitive	0.347–2.08	0.4–0.5 (undrained)
Medium stiff to stiff	2.08–6.94	
Very stiff	6.94–13.89	
Loess	2.08–8.33	0.1–0.3
Silt	0.278–2.78	0.3–0.35
Fine Sand:		
Loose	1.11–1.67	0.25
Medium dense	1.67–2.78	
Dense	2.78–4.17	
Sand:		
Loose	1.39–4.17	0.20–0.36
Medium dense	4.17–6.94	
Dense	6.94–11.11	0.30–0.40
Gravel:		
Loose	4.17–11.11	0.20–0.35
Medium dense	11.11–13.89	
Dense	13.89–27.78	0.30–0.40

Estimating E_s from *SPT N* Value	
Soil Type	E_s (ksi)
Silts, sandy silts, slightly cohesive mixtures	0.056 N_{160}
Clean fine to medium sands and slightly silty sands	0.097 N_{160}
Coarse sands and sands with little gravel	0.139 N_{160}
Sandy gravel and gravels	0.167 N_{160}

Estimating E_s from q_c (static cone resistance)	
Sandy soils	$0.028q_c$

ESU 1A Loose to Medium Dense Coarse-Grained Fill
Es = 2.3 ksi = 330 ksf

ESU 2A Very Loose to Loose Sand/ Gravel
Es = 3.7 ksi = 530 ksf

ESU 2B Medium Dense Sand/Gravel
Es = 5.6 ksi = 800 ksf

ESU 4B Dense to Very Dense Sand/Gravel
Es = 0.167*111 = 18.5 ksi = 2670 ksf

The modulus of elasticity for normally consolidated granular soils tends to increase with depth. An alternative method of defining the soil modulus for granular soils is to assume that it increases linearly with depth starting at zero at the ground surface in accordance with the following equation:

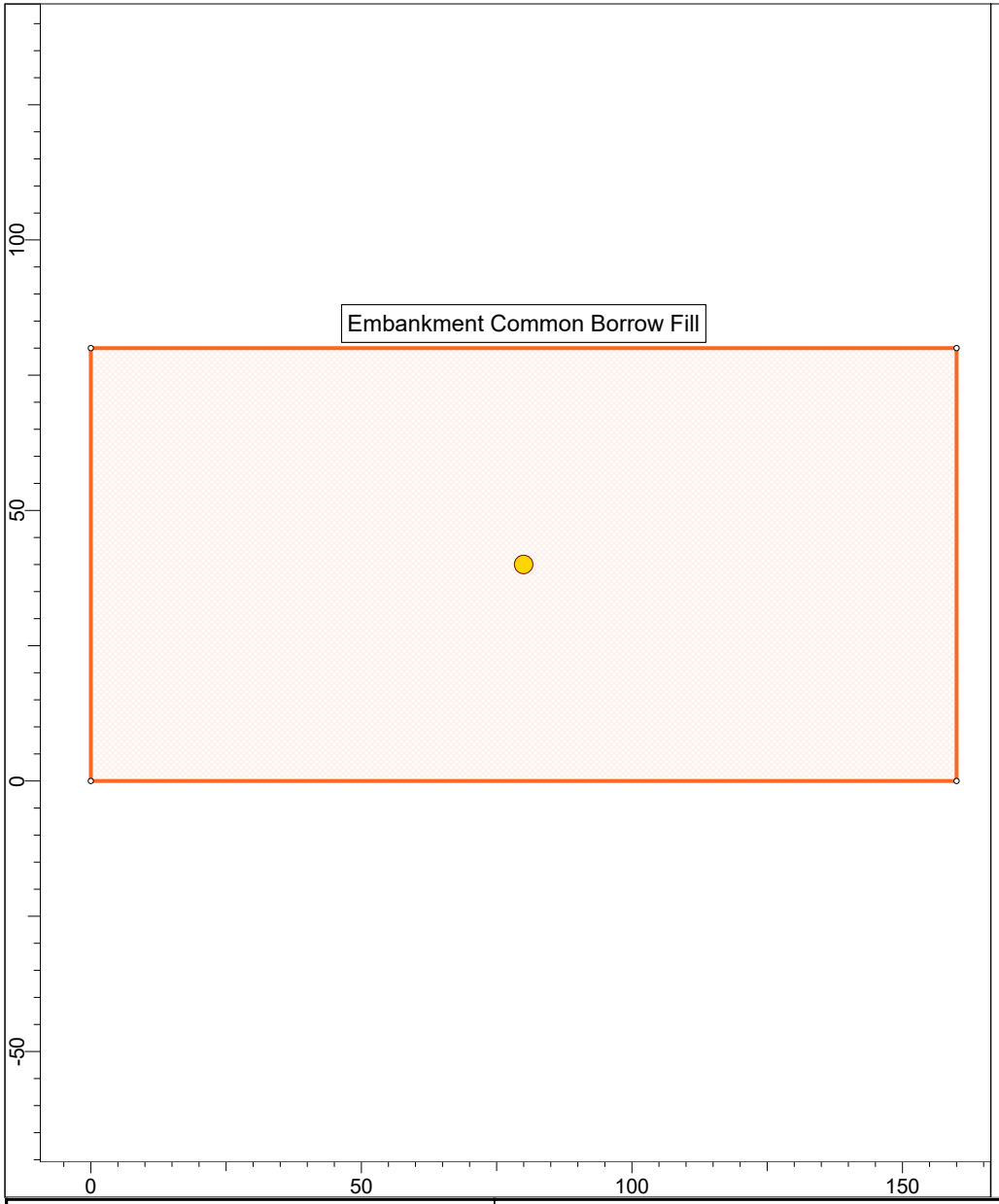
$$E_s = nh \times z \qquad \text{(C10.4.6.3-1)}$$

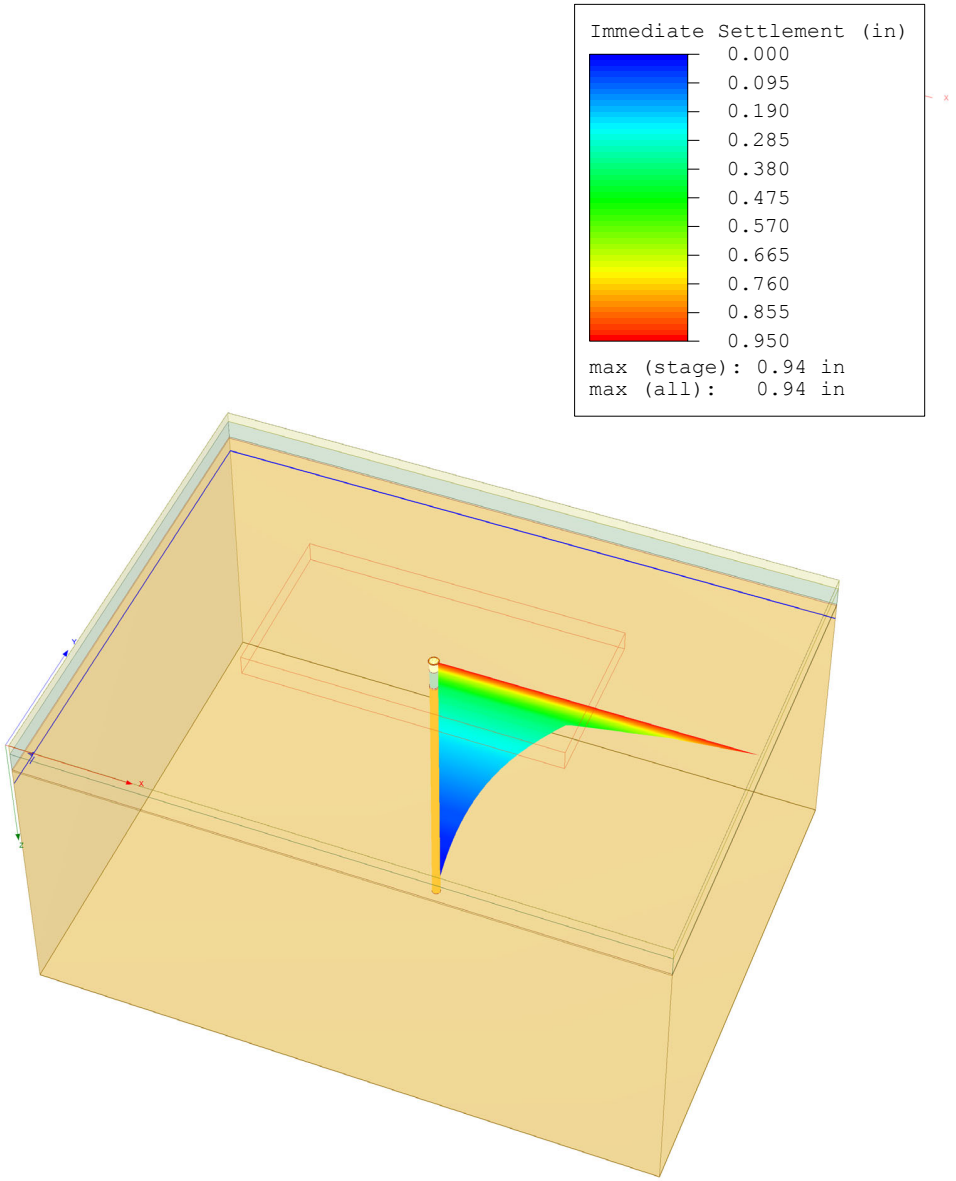
where:

Appendix G.3 - Embankment EMB: I-405 SB MP 5.97 to 5.83

(See Wall 05.85L-A Appendix E.3

for Complete Design Calculations)

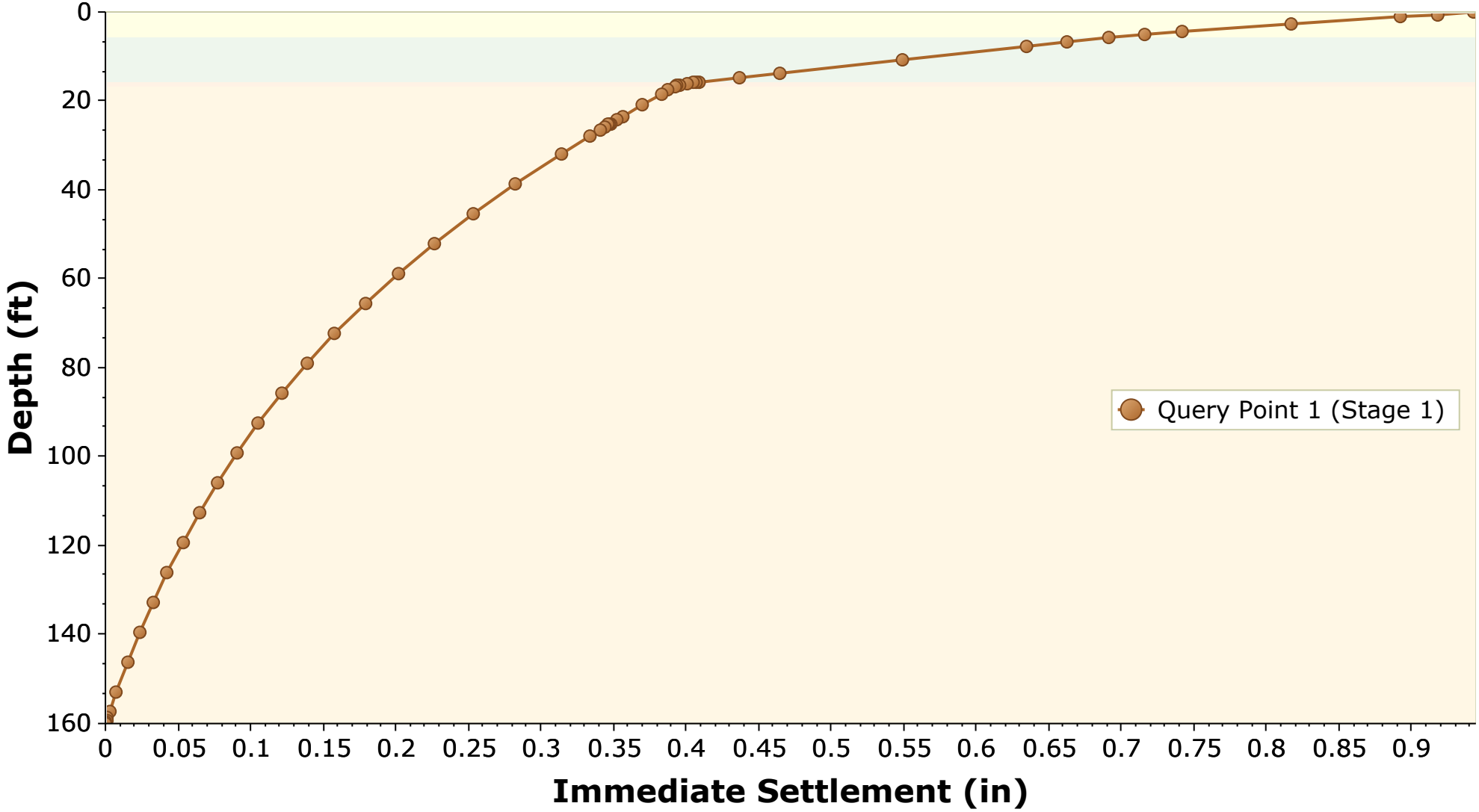




rocscience	*Project*	I-405/Renton to Bellevue Corridor Widening	
	Analysis Description	EMB I-405 SB MP 5.97 to 5.83	
	Drawn By	*Company*	GeoEngineers, Inc
	Date	8/4/2021, 11:49:41 AM	*File Name* EMB I-405 SB MP 5.97 to 5.83 Settlement.s3z

SETTLE3 5.012

Immediate Settlement vs. Depth

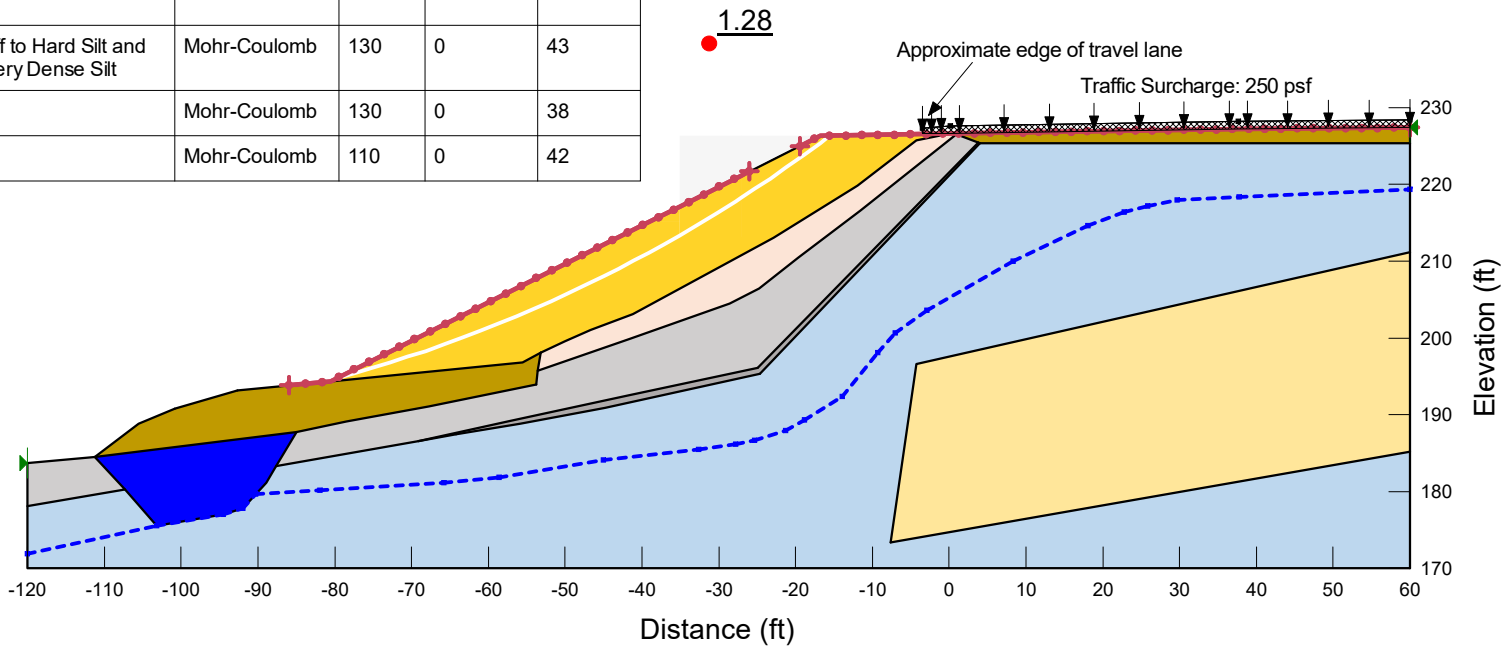


Reference Stage: None

rocscience	Project	I-405/Renton to Bellevue Corridor Widening	
	Analysis Description	EMB I-405 SB MP 5.97 to 5.83	
	Drawn By	Company	GeoEngineers, Inc
	Date	8/4/2021, 11:49:41 AM	File Name: EMB I-405 SB MP 5.97 to 5.83 Settlement.s3z

SETTLE3 5.012

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A Loose to Med Dense Granular Fill (Original)	Mohr-Coulomb	110	0	34
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	15	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Quarry Spalls	Mohr-Coulomb	110	0	42



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

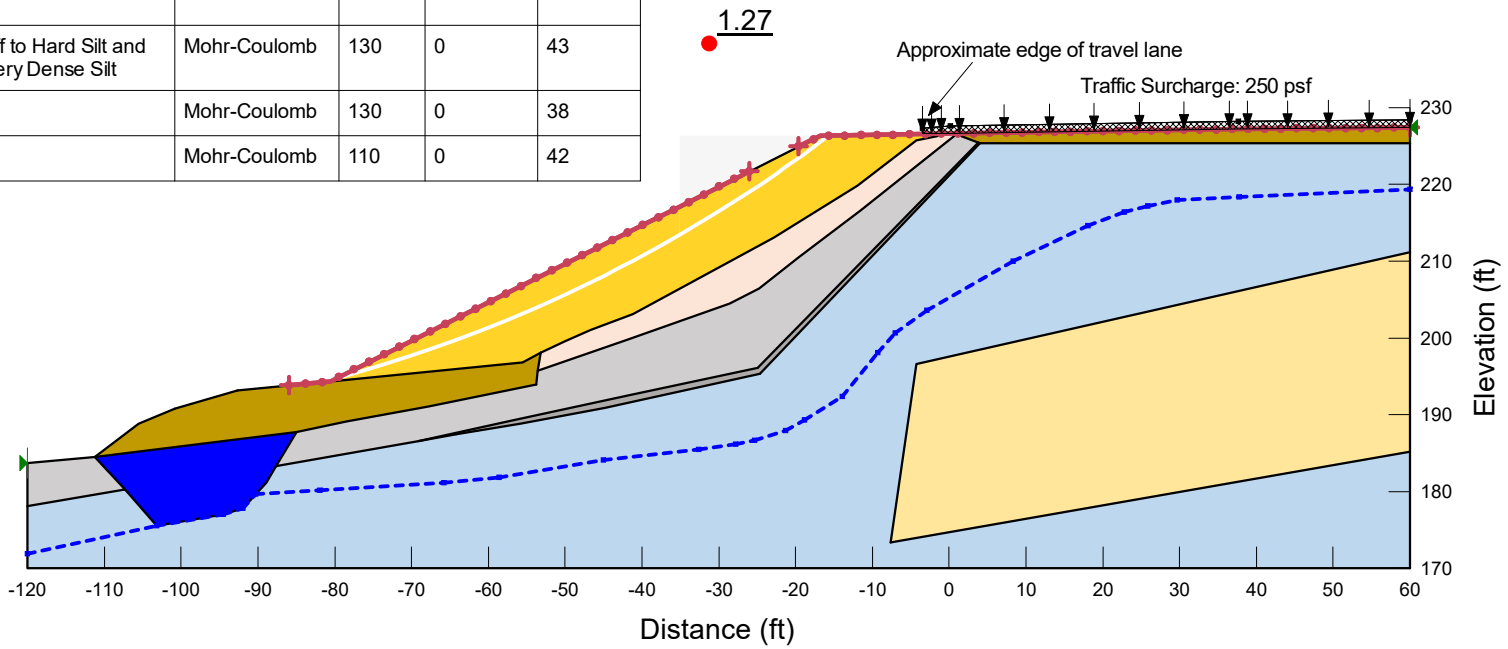
00180-366-01 Date Exported: 08/05/21

EMB I-405 SB MP 5.97 to 5.83 - MP 5.88
Static Global Stability (Spencer)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

Color	Name	Slope Stability Material Model	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Common Borrow	Mohr-Coulomb	120	0	32
	ESU 1A Loose to Med Dense Granular Fill (Original)	Mohr-Coulomb	110	0	34
	ESU 2A Very Loose to Loose Sand/Gravel	Mohr-Coulomb	110	15	32
	ESU 2B Medium Dense Sand/Gravel	Mohr-Coulomb	110	0	32
	ESU 4B Dense to Very Dense Sand/Gravel	Mohr-Coulomb	130	0	43
	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	Mohr-Coulomb	130	0	43
	Gravel Borrow	Mohr-Coulomb	130	0	38
	Quarry Spalls	Mohr-Coulomb	110	0	42



Notes:

1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. GeoEngineers, Inc. cannot guarantee the accuracy and context of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

00180-366-01 Date Exported: 04/26/21

EMB I-405 SB MP 5.97 to 5.83 - MP 5.88
Static Global Stability (M-P)

I-405/Renton to Bellevue Corridor Widening
King County, Washington

GeoEngineers

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In Association with

Appendix H
Settle3 Reports

rocscience

I-405/Renton to Bellevue Corridor Widening
GeoEngineers, Inc
Report Creation Date: 2021/09/23, 13:17:29

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Piezometric Line Entities 9

Settle3 Analysis Information

I-405/Renton to Bellevue Corridor Widening

Project Settings

Document Name	EMB I-405 SB MP 5.97 to 5.83 Settlement.s3z
Project Title	I-405/Renton to Bellevue Corridor Widening
Analysis	EMB I-405 SB MP 5.97 to 5.83
Company	GeoEngineers, Inc
Date Created	8/4/2021, 11:49:41 AM
Comments	
Stress Computation Method	Boussinesq
Minimum settlement ratio for subgrade modulus	0.9
Use average properties to calculate layered stresses	
Improve consolidation accuracy	
Ignore negative effective stresses in settlement calculations	

Stage Settings

Stage #	Name
1	Stage 1

Results

Time taken to compute: 0.101 seconds

Stage: Stage 1

Data Type	Minimum	Maximum
Total Settlement [in]	0	0.942966
Total Consolidation Settlement [in]	0	0
Virgin Consolidation Settlement [in]	0	0
Recompression Consolidation Settlement [in]	0	0
Immediate Settlement [in]	0	0.942966
Loading Stress ZZ [ksf]	0.235002	1.236
Loading Stress XX [ksf]	-0.0299009	0.713296
Loading Stress YY [ksf]	-0.00232925	1.0171
Effective Stress ZZ [ksf]	1.236	12.2832
Effective Stress XX [ksf]	0.713296	12.0208
Effective Stress YY [ksf]	1.0171	12.0459
Total Stress ZZ [ksf]	1.236	20.701
Total Stress XX [ksf]	0.713296	20.4386
Total Stress YY [ksf]	1.0171	20.4637
Modulus of Subgrade Reaction (Total) [ksf/ft]	0	16.6161
Modulus of Subgrade Reaction (Immediate) [ksf/ft]	0	16.6161
Modulus of Subgrade Reaction (Consolidation) [ksf/ft]	0	0
Total Strain	8.80751e-05	0.00374545
Pore Water Pressure [ksf]	0	8.41776
Degree of Consolidation [%]	0	0
Pre-consolidation Stress [ksf]	1.2668	12.2788
Over-consolidation Ratio	1	1
Void Ratio	0	0
Hydroconsolidation Settlement [in]	0	0
Undrained Shear Strength	0	0.0399303

Loads

1. Fill Load: "Embankment Common Borrow Fill"

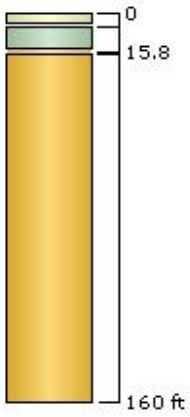
Label	Embankment Common Borrow Fill
Load Type	Flexible
Area of Load	12800 ft2
Load	1.236 ksf
Depth	0 ft
Installation Stage	Stage 1

Coordinates

X [ft]	Y [ft]
160	0
160	80
0	80
0	0

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	ESU 1A	5.6	0
2	ESU 2A	10.2	5.6
3	ESU 2B	0.9	15.8
4	ESU 4B	143.3	16.7



Soil Properties

Property	ESU 1A	ESU 2A	ESU 2B	ESU 4B
Color				
Unit Weight [kips/ft3]	0.11	0.11	0.11	0.13
Saturated Unit Weight [kips/ft3]	0.11	0.11	0.11	0.13
K0	1	1	1	1
Immediate Settlement	Enabled	Enabled	Enabled	Enabled
Es [ksf]	330	530	800	2670
Esur [ksf]	330	530	800	2670
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	0	0	0	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Depth (ft)
1	25.1 ft

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In Association with

Appendix I
Seep/W Reports

Steady State

Report generated using GeoStudio 2020. Copyright © 1991-2020 GEOSLOPE International Ltd.

File Information

File Version: 10.02
Created By: Jon Cracolici
Last Edited By: Carl Longton
Revision Number: 428
Date: 04/09/2021
Time: 08:48:55 AM
Tool Version: 10.2.1.19666
File Name: Wall 05.85L-A - Sta 1+90 - 0.8H (No Coh).gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\Wall 05.85L-A\04-02-21\
Last Solved Date: 04/09/2021
Last Solved Time: 08:49:04 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Steady State

Kind: SEEP/W
Method: Steady-State
Physics
- Water Transfer
  - Free convection: thermal effects: No
  - Free convection: solute effects: No
  - Vapor transfer: isothermal: No
  - Vapor transfer: thermal: No

Water Settings
- Maximum Number of Iterations: 1,200
- Maximum Difference: 0.1
- Significant Digits: 2
- Max # of Reviews: 20
- Under-Relaxation Criteria
  - Initial Rate: 1
  - Minimum Rate: 0.1
  - Rate Reduction Factor: 0.65
  - Reduction Frequency (iterations): 10
- Unit Weight of Water: 62.430189 pcf
- Bulk Modulus of Pore-Fluid: 43,511,321 psf

Time
- Starting Time: 0 sec

Duration: 0 sec
Ending Time: 0 sec

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Hydraulic
- Model: Saturated / Unsaturated
- Vol. WC. Function: 2A
- K-Function: 2A
- Ky'/Kx' Ratio: 0.8
- Rotation: 0 °

ESU 2B Medium Dense Sand/Gravel

Hydraulic
- Model: Saturated / Unsaturated
- Vol. WC. Function: 2B
- K-Function: 2B
- Ky'/Kx' Ratio: 0.5
- Rotation: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Hydraulic
- Model: Saturated / Unsaturated
- Vol. WC. Function: 4B
- K-Function: 4B
- Ky'/Kx' Ratio: 0.025
- Rotation: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Hydraulic
- Model: Saturated / Unsaturated
- Vol. WC. Function: 5B
- K-Function: 5B
- Ky'/Kx' Ratio: 0.005
- Rotation: 0 °

Boundary Conditions

Right Total head constant

- Category: Hydraulic
- Kind: Water Total Head 218 ft
- Review: No

Total head at left side

- Category: Hydraulic
- Kind: Water Total Head 160 ft

Review: No

Flux

Category: Hydraulic
Kind: Water Flux 2.6e-07 ft/sec
Review: No

Water K Functions

2A

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 0.00011 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 0.00011)
Data Point: (0.20885434, 8.9333881e-05)
Data Point: (0.5979899, 7.1249845e-05)
Data Point: (1.7121594, 5.3296999e-05)
Data Point: (4.9022396, 3.5715785e-05)
Data Point: (14.036049, 1.9205855e-05)
Data Point: (40.187891, 5.7423859e-06)
Data Point: (115.06561, 8.39696e-07)
Data Point: (329.45485, 7.8039872e-08)
Data Point: (943.2922, 1.8746458e-09)
Data Point: (2,700.8259, 4.0795911e-11)
Data Point: (7,732.9807, 1.3054938e-12)
Data Point: (22,141.002, 6.1944672e-14)
Data Point: (63,393.92, 3.8288737e-15)
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Data Point: (519,694.7, 1.5844563e-17)
Data Point: (1,487,985.3, 9.0105123e-19)
Data Point: (4,260,386.3, 9.746738e-20)
Data Point: (12,198,300, 5.2298422e-21)
Data Point: (34,926,065, 6.7315785e-22)
Data Point: (1e+08, 6.7315785e-22)
Estimation Properties
Hyd. K-Function Estimation Method: Fredlund-Xing Function
Volume Water Content Function: 2A
Saturated Kx: 0.00011 ft/sec
Maximum Suction: 1e+08 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

2B

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %

Segment Curvature: 100 %
Saturated Kx: 3.3e-05 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 3.3e-05)
Data Point: (0.20885434, 3.299866e-05)
Data Point: (0.5979899, 3.2997094e-05)
Data Point: (1.7121594, 3.2994155e-05)
Data Point: (4.9022396, 3.2987267e-05)
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Data Point: (40.187891, 3.2919439e-05)
Data Point: (115.06561, 2.2304274e-05)
Data Point: (329.45485, 4.2752274e-06)
Data Point: (943.2922, 3.0302083e-07)
Data Point: (2,700.8259, 8.9849806e-09)
Data Point: (7,732.9807, 1.5483062e-10)
Data Point: (22,141.002, 1.0024034e-11)
Data Point: (63,393.92, 6.5084402e-13)
Data Point: (181,508.91, 3.9333429e-14)
Data Point: (519,694.7, 2.9574971e-15)
Data Point: (1,487,985.3, 2.1008717e-16)
Data Point: (4,260,386.3, 1.369693e-17)
Data Point: (12,198,300, 5.1084724e-19)
Data Point: (34,926,065, 5.6398058e-20)
Data Point: (1e+08, 5.6398058e-20)
Estimation Properties
Hyd. K-Function Estimation Method: Fredlund-Xing Function
Volume Water Content Function: 2B
Saturated Kx: 3.3e-05 ft/sec
Maximum Suction: 1e+08 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

5B

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 3.8e-08 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 3.8e-08)
Data Point: (0.20885434, 3.7996746e-08)
Data Point: (0.76200357, 3.7992863e-08)
Data Point: (2.7801646, 3.7987317e-08)
Data Point: (10.143411, 3.7975703e-08)
Data Point: (37.008161, 3.7941901e-08)
Data Point: (135.02401, 3.7814973e-08)
Data Point: (492.63414, 1.9125018e-08)
Data Point: (1,797.3721, 2.0225662e-09)
Data Point: (6,557.6994, 8.5177476e-11)
Data Point: (23,925.719, 1.8463817e-12)

Data Point: (87,292.816, 5.3530075e-14)
Data Point: (318,487.22, 2.8407525e-15)
Data Point: (1,161,998.3, 1.1712864e-16)
Data Point: (4,239,542.6, 4.7285973e-18)
Data Point: (15,467,941, 7.3289464e-20)
Data Point: (56,434,672, 2.2361549e-20)
Data Point: (2.059015e+08, 2.2361549e-20)
Data Point: (7.5123013e+08, 2.2361549e-20)
Data Point: (2.7408578e+09, 2.2361549e-20)
Data Point: (1e+10, 2.2361549e-20)

Estimation Properties
Hyd. K-Function Estimation Method: Fredlund-Xing Function
Volume Water Content Function: 5B
Saturated Kx: 3.8e-08 ft/sec
Maximum Suction: 1e+10 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

4B

Model: Hyd K Data Point Function
Function: Water X-Conductivity vs. Water Pressure
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Saturated Kx: 3.8e-07 ft/sec
Data Points: Matric Suction (psf), Water X-Conductivity (ft/sec)
Data Point: (0, 3.8e-07)
Data Point: (0.20885434, 3.7950884e-07)
Data Point: (0.67503366, 3.7788512e-07)
Data Point: (2.1817619, 3.7204474e-07)
Data Point: (7.051626, 3.5178458e-07)
Data Point: (22.79141, 2.9145936e-07)
Data Point: (73.663629, 1.5126527e-07)
Data Point: (238.08664, 1.9915981e-08)
Data Point: (769.51476, 4.4819192e-10)
Data Point: (2,487.1322, 5.4439896e-12)
Data Point: (8,038.6069, 1.2190828e-13)
Data Point: (25,981.41, 4.1653601e-15)
Data Point: (83,973.96, 1.9402147e-16)
Data Point: (271,410.44, 9.7218954e-18)
Data Point: (877,219.9, 4.8068369e-19)
Data Point: (2,835,243.7, 2.3331535e-20)
Data Point: (9,163,730.7, 8.5897964e-22)
Data Point: (29,617,898, 3.0771945e-23)
Data Point: (95,727,377, 3.0771945e-23)
Data Point: (3.0939841e+08, 3.0771945e-23)
Data Point: (1e+09, 3.0771945e-23)

Estimation Properties
Hyd. K-Function Estimation Method: Fredlund-Xing Function
Volume Water Content Function: Vol. Water Content Function 5
Saturated Kx: 3.8e-07 ft/sec

Maximum Suction: 1e+09 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Vol. Water Content Functions

2B

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 1.6e-06 /psf
Saturated Water Content: 0.25847892
Residual Water Content: 0.025847892
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.25847892
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.26)
Data Point: (0.20885434, 0.25999914)
Data Point: (1.0263211, 0.25998986)
Data Point: (5.0433953, 0.25987244)
Data Point: (24.783507, 0.25836008)
Data Point: (121.78744, 0.24045669)
Data Point: (598.46982, 0.14136566)
Data Point: (2,940.9118, 0.05386754)
Data Point: (14,451.794, 0.026960934)
Data Point: (71,016.866, 0.015657812)
Data Point: (348,980.57, 0.0087977367)
Data Point: (1,714,908.7, 0.0042703917)
Data Point: (8,427,150.5, 0.0012637314)
Data Point: (41,411,456, -0.00079695154)
Data Point: (2.0349805e+08, -0.0022645468)
Data Point: (1e+09, -0.0033454343)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.26
Sample Material: Silt
Liquid Limit: 38 %
Diameter at 10% passing: 0.03
Diameter at 60% passing: 0.29
Maximum Suction: 1e+09 psf
Minimum Suction: 0.20885434 psf
Num. Points: 15

2A

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 0.0016 /psf
Saturated Water Content: 0.32852554
Residual Water Content: 0.032852554

Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.32852554
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.25)
Data Point: (0.20885434, 0.24999684)
Data Point: (0.46927854, 0.24998884)
Data Point: (1.0544303, 0.24996032)
Data Point: (2.3692182, 0.24985846)
Data Point: (5.3234385, 0.24949445)
Data Point: (11.961329, 0.24819935)
Data Point: (26.876122, 0.2436797)
Data Point: (60.388438, 0.22894402)
Data Point: (135.68786, 0.18991252)
Data Point: (304.87946, 0.12553108)
Data Point: (685.03908, 0.070438829)
Data Point: (1,539.2265, 0.040711103)
Data Point: (3,458.5154, 0.026089671)
Data Point: (7,770.9998, 0.01820571)
Data Point: (17,460.798, 0.013394317)
Data Point: (39,232.977, 0.010098407)
Data Point: (88,153.274, 0.0076211802)
Data Point: (198,073.16, 0.0056608452)
Data Point: (445,054.11, 0.0040908298)
Data Point: (1,000,000, 0.002838267)
Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.25
Sample Material: Silty Sand
Liquid Limit: 25 %
Diameter at 10% passing: 0.04
Diameter at 60% passing: 0.57
Maximum Suction: 1,000,000 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

5B

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 6.6e-07 /psf
Saturated Water Content: 0.29968497
Residual Water Content: 0.029968497
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.29968497
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.3)
Data Point: (0.20885434, 0.29999961)
Data Point: (1.3967379, 0.29999522)
Data Point: (9.3408478, 0.29993071)

Data Point: (62.468013, 0.29890928)
Data Point: (417.76215, 0.28356122)
Data Point: (2,793.8332, 0.18393497)
Data Point: (18,684.087, 0.09044456)
Data Point: (124,952.02, 0.050132829)
Data Point: (835,631.23, 0.025233608)
Data Point: (5,588,381.6, 0.0085088796)
Data Point: (37,372,956, -0.0031902541)
Data Point: (2.4993602e+08, -0.011859391)
Data Point: (1.6714764e+09, -0.018604408)
Data Point: (1.1178194e+10, -0.024051087)
Data Point: (7.4755479e+10, -0.028576013)
Data Point: (4.9993601e+11, -0.032419581)
Data Point: (3.3433806e+12, -0.035742976)
Data Point: (2.2359249e+13, -0.038658693)
Data Point: (1.4953009e+14, -0.041247871)
Data Point: (1e+15, -0.04357067)

Estimation Properties
Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.3
Sample Material: Clay
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 1e+15 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

4B

Model: Vol WC Data Point Function
Function: Volumetric Water Content vs. Water Pressure
Compressibility: 6.6e-07 /psf
Saturated Water Content: 0.21000004
Residual Water Content: 0.021000004
Curve Fit to Data: 100 %
Segment Curvature: 100 %
Porosity: 0.21000004
Data Points: Matric Suction (psf), Volumetric Water Content
Data Point: (0, 0.21)
Data Point: (0.20885434, 0.20999735)
Data Point: (0.5979899, 0.2099863)
Data Point: (1.7121594, 0.20992864)
Data Point: (4.9022396, 0.20962695)
Data Point: (14.036049, 0.20805808)
Data Point: (40.187891, 0.20023981)
Data Point: (115.06561, 0.16838213)
Data Point: (329.45485, 0.10016865)
Data Point: (943.2922, 0.047118847)
Data Point: (2,700.8259, 0.024843159)
Data Point: (7,732.9807, 0.01532325)

Data Point: (22,141.002, 0.01034229)
Data Point: (63,393.92, 0.007187387)
Data Point: (181,508.91, 0.004915693)
Data Point: (519,694.7, 0.0032158143)
Data Point: (1,487,985.3, 0.0019491585)
Data Point: (4,260,386.3, 0.0010055093)
Data Point: (12,198,300, 0.00029514708)
Data Point: (34,926,065, -0.00024768896)
Data Point: (1e+08, -0.00066891256)

Estimation Properties

Vol. WC Estimation Method: Sample functions
Saturated Water Content: 0.21
Sample Material: Silty Sand
Liquid Limit: 0 %
Diameter at 10% passing: 0
Diameter at 60% passing: 0
Maximum Suction: 1e+08 psf
Minimum Suction: 0.20885434 psf
Num. Points: 20

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	-14.745 ft	165.2079 ft
Point 12	0 ft	211.7 ft
Point 13	0 ft	192 ft
Point 14	15.8 ft	192 ft
Point 15	15.8 ft	211.7 ft
Point 16	13 ft	192 ft
Point 17	17.3 ft	209.4 ft

Point 18	17.3 ft	192 ft
Point 19	17.3 ft	196 ft
Point 20	17.3 ft	198 ft
Point 21	41.8 ft	220.7 ft
Point 22	39.4 ft	223.2 ft
Point 23	26.6 ft	215.4 ft
Point 24	37.9 ft	223.2 ft
Point 25	6.13959 ft	185.3 ft
Point 26	-58.7 ft	160 ft
Point 27	8.9 ft	192 ft
Point 28	-100 ft	160 ft
Point 29	-100 ft	170.1 ft
Point 30	-91.8 ft	174.4 ft
Point 31	-88.3 ft	176.5 ft
Point 32	-85.7 ft	177.8 ft
Point 33	-83.4 ft	178.4 ft
Point 34	-76 ft	178.9 ft
Point 35	-74 ft	179.7 ft
Point 36	-55.9 ft	180.2 ft
Point 37	-37.3 ft	182.3 ft
Point 38	-30.3 ft	182.9 ft
Point 39	-13.6 ft	190.2 ft
Point 40	0 ft	195 ft
Point 41	7 ft	223 ft

Point 42	15 ft	223 ft
Point 43	15 ft	211.7 ft
Point 44	7 ft	211.7 ft
Point 45	-4 ft	196.2 ft
Point 46	28.4 ft	208.3 ft
Point 47	30.5 ft	208.5 ft
Point 48	17.3 ft	206.4 ft
Point 49	23.3 ft	207.4 ft
Point 50	-37.3275 ft	162.2725 ft
Point 51	-47.26 ft	160 ft
Point 52	-35.7 ft	164.7 ft
Point 53	-5.125 ft	182.98095 ft
Point 54	80.7025 ft	160 ft
Point 55	-100 ft	129.8675 ft
Point 56	100 ft	129.8675 ft
Point 57	-100 ft	147.8625 ft
Point 58	-27.95 ft	152.3875 ft
Point 59	-100 ft	133.97 ft
Point 60	15.8 ft	196.6 ft
Point 61	15.8 ft	194.7 ft
Point 62	47.6775 ft	208.84 ft
Point 63	100 ft	209.9025 ft
Point 64	95.42762 ft	209.80965 ft
Point 65	3.915 ft	160.77581 ft

Point 66	17.7925 ft	187.09412 ft
Point 67	2.11662 ft	161.95136 ft
Point 68	-26.69893 ft	160 ft
Point 69	28.7 ft	129.8675 ft
Point 70	15.8 ft	208.5 ft
Point 71	0 ft	198.7 ft
Point 72	47.15 ft	195.68393 ft
Point 73	-6.48 ft	194.6 ft
Point 74	17.3 ft	194.753 ft
Point 75	15.8 ft	194.69918 ft
Point 76	12.0389 ft	194.2 ft
Point 77	0 ft	193.99246 ft
Point 78	42.67 ft	194.37311 ft
Point 79	-8.4 ft	192.9 ft
Point 80	17.3 ft	193.63688 ft
Point 81	15.8 ft	193.58544 ft
Point 82	14.51892 ft	193.40778 ft
Point 83	10.54633 ft	193.27156 ft
Point 84	0 ft	192.9 ft
Point 85	-32.3 ft	165.4 ft
Point 86	-6.9 ft	172.7 ft
Point 87	-100 ft	150.0525 ft
Point 88	-12 ft	170.6 ft
Point 89	-18.785 ft	168.6 ft

Point 90	-71.0125 ft	157.56 ft
Point 91	-77.8075 ft	155.915 ft
Point 92	-79.7925 ft	155.915 ft
Point 93	-80.36 ft	155.4225 ft
Point 94	-97.6 ft	151.41 ft

Lines

	Start Point	End Point	Hydraulic Boundary	Length	Angle
Line 1	1	2	Right Total head constant	25.5 ft	90 °
Line 2	4	7	Right Total head constant	8.4925 ft	90 °
Line 3	7	8		57.418 ft	-0.212 °
Line 4	7	10		3.96 ft	90 °
Line 5	10	9		59.801 ft	0.383 °
Line 6	11	6		7.4896 ft	44.1 °
Line 7	14	16		2.8 ft	0 °
Line 8	18	14		1.5 ft	0 °
Line 9	17	15		2.7459 ft	-56.9 °
Line 10	19	20		2 ft	90 °
Line 11	9	21		2.9682 ft	-57.4 °
Line 12	21	8		1.1535 ft	-47.3 °
Line 13	22	9		0.8 ft	0 °
Line 14	17	23	Flux	11.068 ft	32.8 °
Line 15	23	24	Flux	13.731 ft	34.6 °
Line 16	24	22		1.5 ft	0 °
Line 17	16	25		9.5893 ft	44.3 °
Line 18	25	5		3.2808 ft	44.5 °
Line 19	27	16		4.1 ft	0 °
Line 20	26	28		41.3 ft	0 °
Line 21	28	29		10.1 ft	90 °
Line 22	29	30	Flux	9.259 ft	27.7 °
Line 23	30	31	Flux	4.0817 ft	31 °
Line 24	31	32	Flux	2.9069 ft	26.6 °
Line 25	32	33	Flux	2.377 ft	14.6 °
Line 26	33	34	Flux	7.4169 ft	3.87 °
Line 27	34	35	Flux	2.1541 ft	21.8 °
Line 28	35	36	Flux	18.107 ft	1.58 °
Line 29	36	37	Flux	18.718 ft	6.44 °
Line 30	37	38	Flux	7.0257 ft	4.9 °
Line 31	38	39	Flux	18.226 ft	23.6 °
Line 32	15	43		0.8 ft	0 °

Line 33	43	44		8 ft	0 °
Line 34	44	12		7 ft	0 °
Line 35	41	42		8 ft	0 °
Line 36	42	43		11.3 ft	90 °
Line 37	44	41		11.3 ft	90 °
Line 38	24	42		22.901 ft	0.5 °
Line 39	20	46		15.143 ft	42.9 °
Line 40	46	21		18.257 ft	42.8 °
Line 41	8	47		16.579 ft	43.2 °
Line 42	47	19		18.179 ft	43.4 °
Line 43	46	47		2.1095 ft	5.44 °
Line 44	20	48		8.4 ft	90 °
Line 45	48	17		3 ft	90 °
Line 46	46	49		5.1788 ft	10 °
Line 47	49	48		6.0828 ft	9.46 °
Line 48	50	51		10.189 ft	12.9 °
Line 49	26	51		11.44 ft	0 °
Line 50	13	27		8.9 ft	0 °
Line 51	53	27		16.675 ft	32.7 °
Line 52	3	54		79.802 ft	0 °
Line 53	54	1		19.297 ft	0 °
Line 54	56	1	Right Total head constant	30.132 ft	90 °
Line 55	51	57		54.119 ft	13 °
Line 56	6	58		10.915 ft	44.2 °
Line 57	57	59	Total head at left side	13.893 ft	90 °
Line 58	59	55	Total head at left side	4.1025 ft	90 °
Line 59	58	59		74.367 ft	14.3 °
Line 60	3	58		29.837 ft	14.8 °
Line 61	60	20		2.0518 ft	43 °
Line 62	61	60		1.9 ft	90 °
Line 63	61	19		1.9849 ft	40.9 °
Line 64	2	63	Right Total head constant	24.403 ft	90 °
Line 65	63	4	Right Total head constant	1.245 ft	90 °
Line 66	4	64		4.7641 ft	16.3 °
Line 67	63	64		4.5733 ft	1.16 °
Line 68	64	62		47.76 ft	1.16 °
Line 69	62	47		17.181 ft	1.13 °
Line 70	2	65		99.215 ft	14.4 °
Line 71	65	3		3.1132 ft	14.4 °
Line 72	66	5		14.579 ft	16.3 °
Line 73	67	65		2.1485 ft	-33.2 °

Line 74	67	3		2.2996 ft	58.1 °
Line 75	51	68		20.561 ft	0 °
Line 76	68	6		6.5714 ft	0 °
Line 77	55	69		128.7 ft	0 °
Line 78	69	56		71.3 ft	0 °
Line 79	60	70		11.9 ft	90 °
Line 80	70	15		3.2 ft	90 °
Line 81	17	70		1.7493 ft	31 °
Line 82	12	71		13 ft	90 °
Line 83	71	40		3.7 ft	90 °
Line 84	70	71	Flux	18.592 ft	31.8 °
Line 85	71	45	Flux	4.717 ft	32 °
Line 86	64	72		50.302 ft	16.3 °
Line 87	73	45	Flux	2.9513 ft	32.8 °
Line 88	19	74		1.247 ft	90 °
Line 89	75	61		0.00082 ft	90 °
Line 90	76	60		4.4616 ft	32.5 °
Line 91	40	77		1.0075 ft	90 °
Line 92	72	78		4.6678 ft	16.3 °
Line 93	78	66		25.921 ft	16.3 °
Line 94	39	79	Flux	5.8592 ft	27.4 °
Line 95	79	73	Flux	2.5644 ft	41.5 °
Line 96	74	80		1.1161 ft	90 °
Line 97	80	18		1.6369 ft	90 °

Line 98	14	81		1.5854 ft	90 °
Line 99	81	75		1.1137 ft	90 °
Line 100	16	82		2.071 ft	42.8 °
Line 101	27	83		2.0802 ft	37.7 °
Line 102	83	76		1.7578 ft	31.9 °
Line 103	77	84		1.0925 ft	90 °
Line 104	84	13		0.9 ft	90 °
Line 105	84	79		8.4 ft	0 °
Line 106	11	86		10.848 ft	43.7 °
Line 107	85	50		5.9209 ft	31.9 °
Line 108	53	85		32.366 ft	32.9 °
Line 109	86	5		14.852 ft	43.9 °
Line 110	52	85		3.4713 ft	11.6 °
Line 111	28	87	Total head at left side	9.9475 ft	90 °
Line 112	87	57	Total head at left side	2.19 ft	90 °
Line 113	26	52		23.475 ft	11.5 °
Line 114	88	86		5.5154 ft	22.4 °
Line 115	85	89		13.889 ft	13.3 °
Line 116	89	88		7.0736 ft	16.4 °
Line 117	26	90		12.552 ft	11.2 °
Line 118	90	91		6.9913 ft	13.6 °
Line 119	91	92		1.985 ft	0 °
Line 120	92	93		0.75141 ft	41 °
Line 121	93	94		17.701 ft	13.1 °

Line 122	94	87		2.7573 ft	29.5 °
Line 123	61	82		1.8196 ft	45.2 °

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,65,3,54	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	65,2,63,64,72,78,66,5,86,11,6,58,3,67	2,652.9 ft²
Region 3		9,21,8,7,10	214.55 ft²
Region 4		12,71,70,15,43,44	127.98 ft²
Region 5	ESU 2A Very Loose to Loose Sand/Gravel	15,70,17	2.4 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	47,19,20,46	22.905 ft²
Region 7	ESU 2A Very Loose to Loose Sand/Gravel	21,46,49,48,17,23,24,22,9	146.15 ft²
Region 8		41,42,43,44	90.4 ft²
Region 9		24,42,43,15,17,23	170.39 ft²
Region 10	ESU 2B Medium Dense Sand/Gravel	21,46,47,8	21.242 ft²
Region 11	ESU 2A Very Loose to Loose Sand/Gravel	46,49,48,20	46.47 ft²
Region 12	ESU 2B Medium Dense Sand/Gravel	27,53,85,89,88,86,5,25,16	239.18 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	28,87,94,93,92,91,90,26	183.51 ft²
Region 14	ESU 4B Dense to Very Dense Sand/Gravel	55,69,56,1,54,3,58,59	4,704.7 ft²
Region 15		51,57,59,58,6,68	921.68 ft²

	ESU 2B Medium Dense Sand/Gravel		
Region 16	ESU 2B Medium Dense Sand/Gravel	20,60,61,19	2.925 ft²
Region 17	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	4,64,63	2.8463 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	4,7,8,47,62,64	662.96 ft²
Region 19	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	65,67,3	2.4697 ft²
Region 20	ESU 2B Medium Dense Sand/Gravel	50,51,68,6,11,86,88,89,85	165.47 ft²
Region 21	ESU 2A Very Loose to Loose Sand/Gravel	60,20,48,17,70	17.475 ft²
Region 22	ESU 2A Very Loose to Loose Sand/Gravel	76,60,70,71,40,77,84,13,27,83	166.85 ft²
Region 23	ESU 2A Very Loose to Loose Sand/Gravel	40,71,45,73,79,84,77	26.032 ft²
Region 24	ESU 4B Dense to Very Dense Sand/Gravel	72,64,62,47,19,74,80,18,14,16,25,5,66,78	803.96 ft²
Region 25	ESU 4B Dense to Very Dense Sand/Gravel	74,19,61,75,81,14,18,80	5.025 ft²
Region 26	ESU 4B Dense to	75,61,82,16,14,81	3.7004 ft²

	Very Dense Sand/Gravel		
Region 27	ESU 2A Very Loose to Loose Sand/Gravel	39,38,37,36,35,34,33,32,31,30,29,28,26,52,85,53,27,13,84,79	1,658.1 ft²
Region 28	ESU 2B Medium Dense Sand/Gravel	61,60,76,83,27,16,82	12.725 ft²
Region 29	ESU 2A Very Loose to Loose Sand/Gravel	85,52,26,51,50	40.647 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	26,90,91,92,93,94,87,57,51	136.56 ft²

Mesh Properties

Global Element Size: 5 ft

FLATIRON | LANE | wood.

In Association with

Appendix J
Slope/W Reports – Global Stability

Static - Spencer

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File Information

File Version: 10.02
Title: 05.33R
Created By: Yi Tyan Tsai
Last Edited By: Bo Zhang
Revision Number: 54
Date: 08/03/2021
Time: 12:34:15 PM
Tool Version: 10.2.1.19666
File Name: 05.33R (2020.04).gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\05.33R\
Last Solved Date: 08/03/2021
Last Solved Time: 12:34:28 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Static - Spencer

Kind: SLOPE/W
Method: Spencer
Settings
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings
  - Search Method: Root Finder

Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

4B Dense to V. Dense Sand/Gravel

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Barrier

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

1B Med. Dense to V. Dense Coarse-Grained Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

1C V. Soft to Med. Stiff/V. Loose to Loose Fine-Grained Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-12.8, 123.63441) ft

Left-Zone Right Coordinate: (-2.8, 123.5) ft
Left-Zone Increment: 10
Right Type: Range
Right-Zone Left Coordinate: (-1, 127.47616) ft
Right-Zone Right Coordinate: (11, 130.16923) ft
Right-Zone Increment: 12
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-40, 124) ft
Right Coordinate: (80, 125.5) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-40 ft	117.5 ft
Coordinate 2	80 ft	117.5 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-40 ft	124 ft
Point 2	-1.1 ft	123.5 ft
Point 3	-1.2 ft	126 ft
Point 4	10 ft	130.1 ft
Point 5	23 ft	131 ft
Point 6	80 ft	125.5 ft
Point 7	80 ft	95 ft
Point 8	-40 ft	95 ft
Point 9	-2.8 ft	123.5 ft
Point 10	-2.2 ft	128.5 ft
Point 11	-1.3 ft	128.5 ft
Point 12	-40 ft	115 ft
Point 13	80 ft	115 ft
Point 14	-40 ft	100 ft
Point 15	80 ft	100 ft
Point 16	-1.258888 ft	127.47219 ft
Point 17	3 ft	127.5375 ft

Regions

	Material	Points	Area
Region 1	1B Med. Dense to V. Dense Coarse-Grained Fill	1,9,2,3,17,4,5,6,13,12	1,442.5 ft²
Region 2	Barrier	9,10,11,16,3,2	6.5 ft²
Region 3	4B Dense to V. Dense Sand/Gravel	7,8,14,15	600 ft²
Region 4	1C V. Soft to Med. Stiff/V. Loose to Loose Fine-Grained Fill	12,13,15,14	1,800 ft²
Region 5	Common Borrow	16,17,3	3.1369 ft²

Slip Results

Slip Surfaces Analysed: 611 of 1573 converged

Current Slip Surface

Slip Surface: 900
Factor of Safety: 1.69
Volume: 18.210888 ft³
Weight: 2,380.3065 lbf
Resisting Moment: 10,249.147 lbf·ft
Activating Moment: 6,064.1791 lbf·ft
Resisting Force: 1,459.9305 lbf
Activating Force: 863.55344 lbf
Slip Rank: 1 of 1,573 slip surfaces
Exit: (-6.8, 123.55376) ft
Entry: (2.1139218, 127.52391) ft
Radius: 6.0990083 ft
Center: (-3.831987, 128.88188) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-6.6461539 ft	123.47371 ft	-372.93977 psf	23.616385 psf	17.158308 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 2	-6.3384615 ft	123.32427 ft	-363.61026 psf	59.144735 psf	42.971165 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 3	-6.0307692 ft	123.1954 ft	-355.56477 psf	82.51457 psf	59.950344 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 4	-5.7230769 ft	123.08572 ft	-348.71729 psf	97.860875 psf	71.100088 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice	-5.4153846	122.99415	-343.00063	107.52192	78.11925	0 psf	0 psf	1B Med.

5	ft	ft	psf	psf	psf			Dense to V. Dense Coarse-Grained Fill
Slice 6	-5.1076923 ft	122.91985 ft	-338.36251 psf	112.92261 psf	82.043081 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 7	-4.8 ft	122.8622 ft	-334.76288 psf	114.98584 psf	83.542104 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 8	-4.4923077 ft	122.8207 ft	-332.17202 psf	114.34018 psf	83.073006 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 9	-4.1846154 ft	122.79502 ft	-330.56925 psf	111.43213 psf	80.960185 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 10	-3.8769231 ft	122.78498 ft	-329.94203 psf	106.59038 psf	77.442445 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 11	-3.5692308 ft	122.79048 ft	-330.28555 psf	100.06453 psf	72.701137 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 12	-3.2615385 ft	122.81157 ft	-331.60243 psf	92.049521 psf	66.877892 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 13	-2.9538462 ft	122.84842 ft	-333.90292 psf	82.701669 psf	60.086279 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 14	-2.65 ft	122.90045 ft	-337.15136 psf	261.60728 psf	190.06882 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 15	-2.35 ft	122.96768 ft	-341.34845 psf	604.73684 psf	439.36703 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 16	-2.05 ft	123.05111 ft	-346.557 psf	743.25263 psf	540.00464 psf	0 psf	0 psf	1B Med. Dense to V.

								Dense Coarse-Grained Fill
Slice 17	-1.75 ft	123.15145 ft	-352.8213 psf	701.01914 psf	509.32022 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 18	-1.45 ft	123.26962 ft	-360.19818 psf	658.83006 psf	478.66805 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 19	-1.279444 ft	123.34275 ft	-364.7641 psf	571.43575 psf	415.17238 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 20	-1.229444 ft	123.36612 ft	-366.22281 psf	483.58869 psf	351.34775 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 21	-1.15 ft	123.40449 ft	-368.61858 psf	425.91465 psf	309.4451 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 22	-0.95795805 ft	123.5049 ft	-374.88686 psf	374.74493 psf	272.26813 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 23	-0.67387415 ft	123.66684 ft	-384.99679 psf	343.89899 psf	249.85724 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 24	-0.38979025 ft	123.85002 ft	-396.4331 psf	312.45317 psf	227.01052 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 25	-0.10570635 ft	124.05689 ft	-409.34775 psf	280.32498 psf	203.66802 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 26	0.17837754 ft	124.29066 ft	-423.94199 psf	247.4273 psf	179.76646 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 27	0.46246144 ft	124.55573 ft	-440.49053 psf	213.66587 psf	155.23734 psf	0 psf	0 psf	1B Med. Dense to V. Dense

								Coarse-Grained Fill
Slice 28	0.74654534 ft	124.85837 ft	-459.38421 psf	178.93709 psf	130.00541 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 29	1.0306292 ft	125.208 ft	-481.21217 psf	143.1273 psf	103.98807 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 30	1.3147131 ft	125.62013 ft	-506.94151 psf	106.11802 psf	77.099253 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 31	1.598797 ft	126.12397 ft	-538.39583 psf	67.813543 psf	49.269423 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 32	1.8828809 ft	126.79211 ft	-580.10825 psf	28.250688 psf	20.525326 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 33	2.0694223 ft	127.35223 ft	-615.07671 psf	5.4652441 psf	3.4150635 psf	0 psf	0 psf	Common Borrow

Static - MP

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File Information

File Version: 10.02
Title: 05.33R
Created By: Yi Tyan Tsai
Last Edited By: Bo Zhang
Revision Number: 54
Date: 08/03/2021
Time: 12:34:15 PM
Tool Version: 10.2.1.19666
File Name: 05.33R (2020.04).gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\05.33R\
Last Solved Date: 08/03/2021
Last Solved Time: 12:34:28 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

Static - MP

Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001

Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

4B Dense to V. Dense Sand/Gravel

Model: Mohr-Coulomb
Unit Weight: 130 pcf
Cohesion': 0 psf
Phi': 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Barrier

Model: High Strength
Unit Weight: 150 pcf
Pore Water Pressure
Piezometric Line: 1

1B Med. Dense to V. Dense Coarse-Grained Fill

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 36 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

1C V. Soft to Med. Stiff/V. Loose to Loose Fine-Grained Fill

Model: Mohr-Coulomb
Unit Weight: 115 pcf
Cohesion': 0 psf
Phi': 27 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-12.8, 123.63441) ft
Left-Zone Right Coordinate: (-2.8, 123.5) ft
Left-Zone Increment: 10
Right Type: Range
Right-Zone Left Coordinate: (-1, 127.47616) ft
Right-Zone Right Coordinate: (11, 130.16923) ft
Right-Zone Increment: 12
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (-40, 124) ft
Right Coordinate: (80, 125.5) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-40 ft	117.5 ft
Coordinate 2	80 ft	117.5 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-40 ft	124 ft
Point 2	-1.1 ft	123.5 ft
Point 3	-1.2 ft	126 ft
Point 4	10 ft	130.1 ft
Point 5	23 ft	131 ft
Point 6	80 ft	125.5 ft
Point 7	80 ft	95 ft
Point 8	-40 ft	95 ft
Point 9	-2.8 ft	123.5 ft
Point 10	-2.2 ft	128.5 ft
Point 11	-1.3 ft	128.5 ft
Point 12	-40 ft	115 ft
Point 13	80 ft	115 ft
Point 14	-40 ft	100 ft
Point 15	80 ft	100 ft

Point 16	-1.258888 ft	127.47219 ft
Point 17	3 ft	127.5375 ft

Regions

	Material	Points	Area
Region 1	1B Med. Dense to V. Dense Coarse-Grained Fill	1,9,2,3,17,4,5,6,13,12	1,442.5 ft²
Region 2	Barrier	9,10,11,16,3,2	6.5 ft²
Region 3	4B Dense to V. Dense Sand/Gravel	7,8,14,15	600 ft²
Region 4	1C V. Soft to Med. Stiff/V. Loose to Loose Fine-Grained Fill	12,13,15,14	1,800 ft²
Region 5	Common Borrow	16,17,3	3.1369 ft²

Slip Results

Slip Surfaces Analysed: 617 of 1573 converged

Current Slip Surface

Slip Surface: 900
Factor of Safety: 1.69
Volume: 18.210888 ft³
Weight: 2,380.3065 lbf
Resisting Moment: 10,261.094 lbf·ft
Activating Moment: 6,064.1791 lbf·ft
Resisting Force: 1,460.2611 lbf
Activating Force: 862.80966 lbf
Slip Rank: 1 of 1,573 slip surfaces
Exit: (-6.8, 123.55376) ft
Entry: (2.1139218, 127.52391) ft
Radius: 6.0990083 ft
Center: (-3.831987, 128.88188) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-6.6461539 ft	123.47371 ft	-372.93977 psf	12.96744 psf	9.4213967 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 2	-6.3384615 ft	123.32427 ft	-363.61026 psf	38.998734 psf	28.334239 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 3	-6.0307692 ft	123.1954 ft	-355.56477 psf	63.877597 psf	46.409791 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 4	-5.7230769 ft	123.08572 ft	-348.71729 psf	86.568582 psf	62.895757 psf	0 psf	0 psf	1B Med. Dense to V. Dense

								Coarse-Grained Fill
Slice 5	-5.4153846 ft	122.99415 ft	-343.00063 psf	105.9731 psf	76.993965 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 6	-5.1076923 ft	122.91985 ft	-338.36251 psf	121.10881 psf	87.990699 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 7	-4.8 ft	122.8622 ft	-334.76288 psf	131.27502 psf	95.376886 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 8	-4.4923077 ft	122.8207 ft	-332.17202 psf	136.15967 psf	98.925791 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 9	-4.1846154 ft	122.79502 ft	-330.56925 psf	135.86395 psf	98.710941 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 10	-3.8769231 ft	122.78498 ft	-329.94203 psf	130.84807 psf	95.06669 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 11	-3.5692308 ft	122.79048 ft	-330.28555 psf	121.82277 psf	88.509425 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 12	-3.2615385 ft	122.81157 ft	-331.60243 psf	109.62064 psf	79.64406 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 13	-2.9538462 ft	122.84842 ft	-333.90292 psf	95.077677 psf	69.077976 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 14	-2.65 ft	122.90045 ft	-337.15136 psf	274.50558 psf	199.43998 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 15	-2.35 ft	122.96768 ft	-341.34845 psf	618.99812 psf	449.72846 psf	0 psf	0 psf	1B Med. Dense to V. Dense

								Coarse-Grained Fill
Slice 16	-2.05 ft	123.05111 ft	-346.557 psf	749.33883 psf	544.42653 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 17	-1.75 ft	123.15145 ft	-352.8213 psf	695.52588 psf	505.32913 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 18	-1.45 ft	123.26962 ft	-360.19818 psf	643.88876 psf	467.81257 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 19	-1.279444 ft	123.34275 ft	-364.7641 psf	552.46877 psf	401.39205 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 20	-1.229444 ft	123.36612 ft	-366.22281 psf	463.90043 psf	337.04339 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 21	-1.15 ft	123.40449 ft	-368.61858 psf	405.12122 psf	294.33779 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 22	-0.95795805 ft	123.5049 ft	-374.88686 psf	351.87095 psf	255.64921 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 23	-0.67387415 ft	123.66684 ft	-384.99679 psf	319.56762 psf	232.17947 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 24	-0.38979025 ft	123.85002 ft	-396.4331 psf	288.87275 psf	209.87834 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 25	-0.10570635 ft	124.05689 ft	-409.34775 psf	259.5312 psf	188.56046 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 26	0.17837754 ft	124.29066 ft	-423.94199 psf	231.17086 psf	167.95546 psf	0 psf	0 psf	1B Med. Dense to V. Dense

								Coarse-Grained Fill
Slice 27	0.46246144 ft	124.55573 ft	-440.49053 psf	203.29655 psf	147.70359 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 28	0.74654534 ft	124.85837 ft	-459.38421 psf	175.26255 psf	127.3357 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 29	1.0306292 ft	125.208 ft	-481.21217 psf	146.21092 psf	106.22845 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 30	1.3147131 ft	125.62013 ft	-506.94151 psf	114.94547 psf	83.512773 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 31	1.598797 ft	126.12397 ft	-538.39583 psf	79.659364 psf	57.875916 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 32	1.8828809 ft	126.79211 ft	-580.10825 psf	37.211468 psf	27.035714 psf	0 psf	0 psf	1B Med. Dense to V. Dense Coarse-Grained Fill
Slice 33	2.0694223 ft	127.35223 ft	-615.07671 psf	8.2645668 psf	5.1642745 psf	0 psf	0 psf	Common Borrow

1.1 Static (Spencer)

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File Information

File Version: 11.01
Title: 05.55L
Created By: Bo Zhang
Last Edited By: Yi Tyan Tsai
Revision Number: 114
Date: 11/17/2021
Time: 03:29:15 PM
Tool Version: 11.1.3.22085
File Name: Wall 05.55L.gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.55L\
Last Solved Date: 11/17/2021
Last Solved Time: 03:29:20 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1.1 Static (Spencer)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: (none)
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3

Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Barrier

Material Model: High Strength
Unit Weight: 150 pcf

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 40 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-20, 164.01845) ft
Left-Zone Right Coordinate: (-5, 168.2) ft
Left-Zone Increment: 10
Right Type: Range
Right-Zone Left Coordinate: (-3, 173.2) ft
Right-Zone Right Coordinate: (20.000081, 172.52168) ft
Right-Zone Increment: 10
Radius Increments: 25

Slip Surface Limits

Left Coordinate: (-40, 159) ft

Right Coordinate: (40, 173.3) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-1.9 ft	174.2 ft
	6 ft	173.9 ft
	20.7 ft	173.5 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-40 ft	150 ft
Point 2	40 ft	150 ft
Point 3	40 ft	155.5 ft
Point 4	-40 ft	156 ft
Point 5	40 ft	172.5 ft
Point 6	37.7 ft	172 ft
Point 7	-3.5 ft	171.7 ft
Point 8	-3.5 ft	167.2 ft
Point 9	-4.5 ft	167.2 ft
Point 10	-12.9 ft	165.8 ft
Point 11	-40 ft	159 ft
Point 12	40 ft	173.3 ft
Point 13	32.4 ft	173.3 ft
Point 14	24.8 ft	172.4 ft
Point 15	-4 ft	176.2 ft
Point 16	-4.5 ft	168.2 ft
Point 17	-3.5 ft	176.2 ft
Point 18	-3 ft	173.2 ft
Point 19	-1.9 ft	173.2 ft
Point 20	20.7 ft	172.5 ft
Point 21	-8.5 ft	168.2 ft
Point 22	-4.5 ft	173.2 ft
Point 23	-4.5 ft	166.2 ft
Point 24	2.5 ft	166.2 ft

Point 25	2.5 ft	167.2 ft
Point 26	-3 ft	172.2 ft
Point 27	12.2 ft	172.76327 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,3,4	460 ft²
Region 2	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	10,11,4,3,5,6,14,20,27,24,23,9,16,21	947.98 ft²
Region 3	Gravel Borrow	5,12,13,14,6	13.185 ft²
Region 4	Barrier	15,22,16,9,8,7,26,18,17	9.625 ft²
Region 5	Barrier	8,9,23,24,25	7 ft²
Region 6	Common Borrow	19,18,26,7,8,25,24,27	68.364 ft²

Slip Results

Slip Surfaces Analysed: 939 of 3146 converged

Current Slip Surface

Slip Surface: 717
Factor of Safety: 2.5
Volume: 132.3351 ft³
Weight: 16,947.146 lbf
Resisting Moment: 303,263.89 lbf·ft
Activating Moment: 121,007.24 lbf·ft
Resisting Force: 14,386.138 lbf
Activating Force: 5,739.9102 lbf
Slip Rank: 1 of 3,146 slip surfaces
Exit: (-16.928791, 164.78909) ft
Entry: (8.500304, 172.87786) ft
Radius: 19.169378 ft
Center: (-8.3864687, 181.94991) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-16.525912 ft	164.60008 ft	0 psf	65.085873 psf	54.613532 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 2	-15.720154 ft	164.2442 ft	0 psf	179.05322 psf	150.24349 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 3	-14.914396 ft	163.93137 ft	0 psf	272.55945 psf	228.70454 psf	0 psf	0 psf	ESU 1B Medium Dense to Very

								Dense Coarse-Grained Fill
Slice 4	-14.108637 ft	163.65937 ft	0 psf	349.75001 psf	293.4751 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 5	-13.302879 ft	163.4264 ft	0 psf	413.55151 psf	347.01092 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 6	-12.46 ft	163.22376 ft	0 psf	490.70543 psf	411.75075 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 7	-11.58 ft	163.05368 ft	0 psf	579.01877 psf	485.85444 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 8	-10.7 ft	162.92581 ft	0 psf	654.15989 psf	548.90533 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 9	-9.82 ft	162.8393 ft	0 psf	717.74647 psf	602.2608 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 10	-8.94 ft	162.79358 ft	0 psf	771.02299 psf	646.96511 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 11	-8.1 ft	162.78684 ft	0 psf	781.76992 psf	655.98285 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 12	-7.3 ft	162.81554 ft	0 psf	754.39416 psf	633.01186 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 13	-6.5 ft	162.87781 ft	0 psf	723.88739 psf	607.41364 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 14	-5.7 ft	162.97401 ft	0 psf	690.38431 psf	579.30122 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 15	-4.9 ft	163.10464 ft	0 psf	653.99959 psf	548.77082 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 16	-4.25 ft	163.23389 ft	0 psf	1,601.8067 psf	1,344.0754 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice	-3.75 ft	163.35147	0 psf	1,772.0636	1,486.9379	0 psf	0 psf	ESU 1B Medium

17		ft		psf	psf			Dense to Very Dense Coarse-Grained Fill
Slice 18	-3.25 ft	163.48333 ft	0 psf	1,382.5782 psf	1,160.1209 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 19	-2.45 ft	163.73209 ft	0 psf	1,076.5243 psf	903.31116 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 20	-1.46 ft	164.08188 ft	0 psf	1,214.3017 psf	1,018.9201 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 21	-0.58 ft	164.44871 ft	0 psf	1,130.3973 psf	948.51596 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 22	0.3 ft	164.86873 ft	0 psf	1,043.8454 psf	875.89031 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 23	1.18 ft	165.346 ft	0 psf	954.51991 psf	800.9373 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 24	2.06 ft	165.88563 ft	0 psf	862.28825 psf	723.54576 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 25	2.8198253 ft	166.40228 ft	0 psf	760.35977 psf	638.01761 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 26	3.6163754 ft	167.01596 ft	0 psf	695.96506 psf	434.88724 psf	0 psf	0 psf	Common Borrow
Slice 27	4.5698253 ft	167.83677 ft	0 psf	592.64722 psf	370.32709 psf	0 psf	0 psf	Common Borrow
Slice 28	5.5232751 ft	168.77784 ft	0 psf	484.43254 psf	302.70705 psf	0 psf	0 psf	Common Borrow
Slice 29	6.4167173 ft	169.7885 ft	0 psf	379.4826 psf	237.12704 psf	0 psf	0 psf	Common Borrow
Slice 30	7.250152 ft	170.88461 ft	0 psf	277.5586 psf	173.43787 psf	0 psf	0 psf	Common Borrow
Slice 31	8.0835867 ft	172.17567 ft	0 psf	171.38997 psf	107.09634 psf	0 psf	0 psf	Common Borrow

1.2 Static (M-P)

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File Information

File Version: 11.01
Title: 05.55L
Created By: Bo Zhang
Last Edited By: Yi Tyan Tsai
Revision Number: 114
Date: 11/17/2021
Time: 03:29:15 PM
Tool Version: 11.1.3.22085
File Name: Wall 05.55L.gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.55L\
Last Solved Date: 11/17/2021
Last Solved Time: 03:29:22 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1.2 Static (M-P)

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: (none)
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings

Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Barrier

Material Model: High Strength
Unit Weight: 150 pcf

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 40 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-20, 164.01845) ft
Left-Zone Right Coordinate: (-5, 168.2) ft
Left-Zone Increment: 10
Right Type: Range
Right-Zone Left Coordinate: (-3, 173.2) ft
Right-Zone Right Coordinate: (20.000081, 172.52168) ft
Right-Zone Increment: 10
Radius Increments: 25

Slip Surface Limits

Left Coordinate: (-40, 159) ft
Right Coordinate: (40, 173.3) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-1.9 ft	174.2 ft
	6 ft	173.9 ft
	20.7 ft	173.5 ft

Geometry

Name: 2D Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	-40 ft	150 ft
Point 2	40 ft	150 ft
Point 3	40 ft	155.5 ft
Point 4	-40 ft	156 ft
Point 5	40 ft	172.5 ft
Point 6	37.7 ft	172 ft
Point 7	-3.5 ft	171.7 ft
Point 8	-3.5 ft	167.2 ft
Point 9	-4.5 ft	167.2 ft
Point 10	-12.9 ft	165.8 ft
Point 11	-40 ft	159 ft
Point 12	40 ft	173.3 ft
Point 13	32.4 ft	173.3 ft
Point 14	24.8 ft	172.4 ft
Point 15	-4 ft	176.2 ft
Point 16	-4.5 ft	168.2 ft
Point 17	-3.5 ft	176.2 ft
Point 18	-3 ft	173.2 ft
Point 19	-1.9 ft	173.2 ft
Point 20	20.7 ft	172.5 ft
Point 21	-8.5 ft	168.2 ft
Point 22	-4.5 ft	173.2 ft

Point 23	-4.5 ft	166.2 ft
Point 24	2.5 ft	166.2 ft
Point 25	2.5 ft	167.2 ft
Point 26	-3 ft	172.2 ft
Point 27	12.2 ft	172.76327 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,3,4	460 ft²
Region 2	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	10,11,4,3,5,6,14,20,27,24,23,9,16,21	947.98 ft²
Region 3	Gravel Borrow	5,12,13,14,6	13.185 ft²
Region 4	Barrier	15,22,16,9,8,7,26,18,17	9.625 ft²
Region 5	Barrier	8,9,23,24,25	7 ft²
Region 6	Common Borrow	19,18,26,7,8,25,24,27	68.364 ft²

Slip Results

Slip Surfaces Analysed: 945 of 3146 converged

Current Slip Surface

Slip Surface: 717
Factor of Safety: 2.5
Volume: 132.3351 ft³
Weight: 16,947.146 lbf
Resisting Moment: 303,216.01 lbf·ft
Activating Moment: 121,007.24 lbf·ft
Resisting Force: 14,380.328 lbf
Activating Force: 5,738.3023 lbf
Slip Rank: 1 of 3,146 slip surfaces
Exit: (-16.928791, 164.78909) ft
Entry: (8.500304, 172.87786) ft
Radius: 19.169378 ft
Center: (-8.3864687, 181.94991) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-16.525912 ft	164.60008 ft	0 psf	46.618237 psf	39.117346 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 2	-15.720154 ft	164.2442 ft	0 psf	140.0721 psf	117.53445 psf	0 psf	0 psf	ESU 1B Medium Dense to Very

								Dense Coarse-Grained Fill
Slice 3	-14.914396 ft	163.93137 ft	0 psf	231.25932 psf	194.04961 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 4	-14.108637 ft	163.65937 ft	0 psf	318.22116 psf	267.01926 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 5	-13.302879 ft	163.4264 ft	0 psf	398.88356 psf	334.70305 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 6	-12.46 ft	163.22376 ft	0 psf	495.46126 psf	415.74136 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 7	-11.58 ft	163.05368 ft	0 psf	604.74308 psf	507.43969 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 8	-10.7 ft	162.92581 ft	0 psf	699.66418 psf	587.08796 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 9	-9.82 ft	162.8393 ft	0 psf	778.44549 psf	653.19332 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 10	-8.94 ft	162.79358 ft	0 psf	840.31702 psf	705.1097 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 11	-8.1 ft	162.78684 ft	0 psf	851.78391 psf	714.73156 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 12	-7.3 ft	162.81554 ft	0 psf	818.03566 psf	686.41342 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 13	-6.5 ft	162.87781 ft	0 psf	776.17952 psf	651.29195 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 14	-5.7 ft	162.97401 ft	0 psf	727.98932 psf	610.85557 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 15	-4.9 ft	163.10464 ft	0 psf	675.10853 psf	566.48332 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice	-4.25 ft	163.23389	0 psf	1,619.7106	1,359.0985	0 psf	0 psf	ESU 1B Medium

16		ft		psf	psf			Dense to Very Dense Coarse-Grained Fill
Slice 17	-3.75 ft	163.35147 ft	0 psf	1,777.9702 psf	1,491.8941 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 18	-3.25 ft	163.48333 ft	0 psf	1,372.7566 psf	1,151.8796 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 19	-2.45 ft	163.73209 ft	0 psf	1,047.5916 psf	879.0337 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 20	-1.46 ft	164.08188 ft	0 psf	1,166.581 psf	978.87766 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 21	-0.58 ft	164.44871 ft	0 psf	1,071.2753 psf	898.90675 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 22	0.3 ft	164.86873 ft	0 psf	979.03828 psf	821.51066 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 23	1.18 ft	165.346 ft	0 psf	889.85921 psf	746.68054 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 24	2.06 ft	165.88563 ft	0 psf	803.31836 psf	674.06414 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 25	2.8198253 ft	166.40228 ft	0 psf	709.77306 psf	595.57031 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 26	3.6163754 ft	167.01596 ft	0 psf	661.85679 psf	413.57402 psf	0 psf	0 psf	Common Borrow
Slice 27	4.5698253 ft	167.83677 ft	0 psf	580.29782 psf	362.61032 psf	0 psf	0 psf	Common Borrow
Slice 28	5.5232751 ft	168.77784 ft	0 psf	495.14958 psf	309.4038 psf	0 psf	0 psf	Common Borrow
Slice 29	6.4167173 ft	169.7885 ft	0 psf	410.14666 psf	256.28808 psf	0 psf	0 psf	Common Borrow
Slice 30	7.250152 ft	170.88461 ft	0 psf	321.72718 psf	201.03745 psf	0 psf	0 psf	Common Borrow
Slice 31	8.0835867 ft	172.17567 ft	0 psf	218.45784 psf	136.50761 psf	0 psf	0 psf	Common Borrow

2A.1 Global - Static (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 651
Date: 01/17/2022
Time: 02:02:35 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:11:18 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.1 Global - Static (Spencer)

Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength

Unit Weight: 130 pcf

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-50, 180.86613) ft
Left-Zone Right Coordinate: (0, 195) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft

Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
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Point 67	22 ft	192 ft
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Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
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Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²

Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²

Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3694 of 16926 converged

Current Slip Surface

Slip Surface: 3,605
Factor of Safety: 1.6
Volume: 1,345.1625 ft³
Weight: 161,577.02 lbf
Resisting Moment: 8,321,638.7 lbf·ft
Activating Moment: 5,136,113.9 lbf·ft
Resisting Force: 102,958.48 lbf
Activating Force: 63,559.906 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-39.462739, 182.05582) ft
Entry: (43.844369, 223.22438) ft
Radius: 68.051682 ft
Center: (-19.83779, 247.21634) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-38.381369 ft	181.74952 ft	-184.72699 psf	85.153074 psf	53.209546 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	181.15543 ft	-184.12592 psf	233.74644 psf	146.06098 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.62304 ft	-182.80161 psf	351.61963 psf	219.71633 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-31.466667 ft	180.17606 ft	-181.52704 psf	443.63975 psf	277.21688 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-28.908333 ft	179.78648 ft	-179.6421 psf	597.47714 psf	373.34515 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.125 ft	179.47013 ft	-178.87824 psf	800.23138 psf	500.04007 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice	-23.341667	179.26921	-178.19734	966.95761	604.22217			ESU 2A Very

7	ft	ft	psf	psf	psf	0 psf	0 psf	Loose to Loose Sand/Gravel
Slice 8	-20.558333 ft	179.1827 ft	-178.33075 psf	1,102.7889 psf	689.09898 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-17.775 ft	179.21018 ft	-185.68001 psf	1,211.6969 psf	757.15227 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-14.991667 ft	179.35177 ft	-198.74798 psf	1,296.8009 psf	810.33113 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-11.747559 ft	179.67303 ft	-344.90271 psf	1,411.3099 psf	881.88429 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-7.9475589 ft	180.24066 ft	-400.29183 psf	1,545.199 psf	965.5475 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-5.5625 ft	180.68028 ft	-362.75844 psf	1,581.3298 psf	988.12451 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.84375 ft	181.08401 ft	-337.22185 psf	1,500.122 psf	937.38029 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.28125 ft	181.75709 ft	-299.62191 psf	1,377.5004 psf	860.75779 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.6775 ft	182.33452 ft	-271.81281 psf	3,335.2082 psf	2,084.0694 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	2.9086702 ft	183.09994 ft	-242.27377 psf	3,240.2196 psf	2,024.7139 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	5.3009652 ft	183.98454 ft	-201.86945 psf	3,238.2228 psf	3,019.6916 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.49909 ft	-177.12016 psf	3,196.286 psf	2,980.5849 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.10525 ft	-156.36495 psf	3,146.2619 psf	2,933.9367 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	10.95 ft	186.57099 ft	-102.19168 psf	3,022.9419 psf	2,818.939 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	14 ft	188.18493 ft	-68.87008 psf	2,873.1038 psf	2,679.2126 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	15.25 ft	188.90859 ft	-61.372977 psf	2,794.2124 psf	2,605.6452 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	16 ft	189.36879 ft	-57.617279 psf	2,744.318 psf	2,559.1179 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
								ESU 4B Dense to

Slice 25	17.50351 ft	190.33736 ft	-50.046546 psf	2,641.3325 psf	2,463.0824 psf	0 psf	0 psf	Very Dense Sand/Gravel
Slice 26	19.25351 ft	191.52011 ft	-43.065855 psf	2,519.3206 psf	2,349.3044 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	20.75 ft	192.60142 ft	-38.792586 psf	2,446.7349 psf	1,911.5988 psf	0 psf	0 psf	Gravel Borrow
Slice 28	22.75 ft	194.16219 ft	-34.625819 psf	2,121.175 psf	1,978.0277 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	24.25 ft	195.37822 ft	-32.143761 psf	2,014.5071 psf	1,878.5582 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	25.2 ft	196.20892 ft	-31.270669 psf	1,913.6562 psf	1,784.5133 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	26.25 ft	197.14917 ft	-30.956212 psf	1,803.5273 psf	1,681.8164 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	27.925 ft	198.77787 ft	-32.204416 psf	1,625.0242 psf	1,515.3596 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	30.575 ft	201.54701 ft	-38.262027 psf	1,346.0204 psf	1,255.1844 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	33.9 ft	205.59165 ft	-58.81759 psf	988.41951 psf	921.7161 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	36.9 ft	209.68543 ft	-104.92924 psf	782.53479 psf	729.72549 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	39.05 ft	213.18728 ft	-190.04655 psf	548.63795 psf	511.61317 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	41 ft	216.77626 ft	-345.23437 psf	353.24361 psf	329.40499 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	42.095707 ft	219.02478 ft	-491.37336 psf	250.9148 psf	233.98184 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	42.448792 ft	219.80479 ft	-545.92821 psf	240.97156 psf	150.57574 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 40	43.17527 ft	221.57977 ft	0 psf	144.59561 psf	112.97047 psf	0 psf	0 psf	Gravel Borrow

2A.2 Global - Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 651
Date: 01/17/2022
Time: 02:02:35 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:03:52 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.2 Global - Static (M-P)

Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-50, 180.86613) ft
Left-Zone Right Coordinate: (0, 195) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
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Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
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Point 18	41.8 ft	220.7 ft
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Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
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Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
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Point 41	-47.26 ft	160 ft
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Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
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Point 59	-32.3 ft	165.4 ft
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Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²

Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²

Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3990 of 16926 converged

Current Slip Surface

Slip Surface: 3,605
Factor of Safety: 1.6
Volume: 1,345.1625 ft³
Weight: 161,577.02 lbf
Resisting Moment: 8,294,301.6 lbf·ft
Activating Moment: 5,136,113.9 lbf·ft
Resisting Force: 102,467.85 lbf
Activating Force: 63,467.659 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-39.462739, 182.05582) ft
Entry: (43.844369, 223.22438) ft
Radius: 68.051682 ft
Center: (-19.83779, 247.21634) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-38.381369 ft	181.74952 ft	-184.72699 psf	55.134939 psf	34.452134 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	181.15543 ft	-184.12592 psf	166.39382 psf	103.9744 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.62304 ft	-182.80161 psf	275.0371 psf	171.86226 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-31.466667 ft	180.17606 ft	-181.52704 psf	377.71346 psf	236.02156 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-28.908333 ft	179.78648 ft	-179.6421 psf	546.6349 psf	341.5754 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.125 ft	179.47013 ft	-178.87824 psf	778.29808 psf	486.33462 psf	0 psf	0 psf	ESU 2A Very Loose to Loose

								Sand/Gravel
Slice 7	-23.341667 ft	179.26921 ft	-178.19734 psf	989.83978 psf	618.52054 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-20.558333 ft	179.1827 ft	-178.33075 psf	1,173.2366 psf	733.11961 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-17.775 ft	179.21018 ft	-185.68001 psf	1,322.5478 psf	826.41956 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-14.991667 ft	179.35177 ft	-198.74798 psf	1,434.5316 psf	896.39484 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-11.747559 ft	179.67303 ft	-344.90271 psf	1,560.1621 psf	974.8975 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-7.9475589 ft	180.24066 ft	-400.29183 psf	1,681.5315 psf	1,050.7375 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-5.5625 ft	180.68028 ft	-362.75844 psf	1,697.3454 psf	1,060.6191 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.84375 ft	181.08401 ft	-337.22185 psf	1,593.6516 psf	995.82402 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.28125 ft	181.75709 ft	-299.62191 psf	1,434.6402 psf	896.46269 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.6775 ft	182.33452 ft	-271.81281 psf	3,384.3579 psf	2,114.7815 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	2.9086702 ft	183.09994 ft	-242.27377 psf	3,246.5967 psf	2,028.6988 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	5.3009652 ft	183.98454 ft	-201.86945 psf	3,279.2817 psf	3,057.9797 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.49909 ft	-177.12016 psf	3,207.5758 psf	2,991.1129 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.10525 ft	-156.36495 psf	3,125.9893 psf	2,915.0322 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	10.95 ft	186.57099 ft	-102.19168 psf	2,941.985 psf	2,743.4454 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	14 ft	188.18493 ft	-68.87008 psf	2,745.3553 psf	2,560.0852 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	15.25 ft	188.90859 ft	-61.372977 psf	2,652.9618 psf	2,473.9269 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice	16 ft	189.36879	-57.617279	2,596.9434	2,421.6889	0 psf	0 psf	ESU 4B Dense to Very Dense

24		ft	psf	psf	psf			Sand/Gravel
Slice 25	17.50351 ft	190.33736 ft	-50.046546 psf	2,485.9406 psf	2,318.1771 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	19.25351 ft	191.52011 ft	-43.065855 psf	2,361.0743 psf	2,201.7374 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	20.75 ft	192.60142 ft	-38.792586 psf	2,292.4167 psf	1,791.0322 psf	0 psf	0 psf	Gravel Borrow
Slice 28	22.75 ft	194.16219 ft	-34.625819 psf	1,982.5396 psf	1,848.7481 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	24.25 ft	195.37822 ft	-32.143761 psf	1,889.7296 psf	1,762.2013 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	25.2 ft	196.20892 ft	-31.270669 psf	1,800.0051 psf	1,678.5319 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	26.25 ft	197.14917 ft	-30.956212 psf	1,703.3399 psf	1,588.3902 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	27.925 ft	198.77787 ft	-32.204416 psf	1,549.6208 psf	1,445.0448 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	30.575 ft	201.54701 ft	-38.262027 psf	1,312.7484 psf	1,224.1577 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	33.9 ft	205.59165 ft	-58.81759 psf	1,006.4394 psf	938.51993 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	36.9 ft	209.68543 ft	-104.92924 psf	851.40818 psf	793.95097 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	39.05 ft	213.18728 ft	-190.04655 psf	631.90823 psf	589.26396 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	41 ft	216.77626 ft	-345.23437 psf	434.73126 psf	405.39346 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	42.095707 ft	219.02478 ft	-491.37336 psf	323.29333 psf	301.47591 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	42.448792 ft	219.80479 ft	-545.92821 psf	347.36838 psf	217.05985 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 40	43.17527 ft	221.57977 ft	0 psf	205.53779 psf	160.58372 psf	0 psf	0 psf	Gravel Borrow

2A.3 Global - Pseudo-Static (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 651
Date: 01/17/2022
Time: 02:02:35 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:08:05 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.3 Global - Pseudo-Static (Spencer)

Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °

Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-50, 180.86613) ft
Left-Zone Right Coordinate: (0, 195) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.19

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft

Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²

Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²

Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 2795 of 16926 converged

Current Slip Surface

Slip Surface: 2,323
Factor of Safety: 1.2
Volume: 1,399.3073 ft³
Weight: 168,087.67 lbf
Resisting Moment: 9,239,657.7 lbf·ft
Activating Moment: 7,442,258.5 lbf·ft
Resisting Force: 107,452.66 lbf
Activating Force: 86,547.964 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-43.677643, 181.57994) ft
Entry: (45.712628, 223.23687) ft
Radius: 74.84631 ft
Center: (-22.766519, 253.44576) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-42.083232 ft	181.15391 ft	-184.13636 psf	460.20823 psf	287.57002 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-38.894411 ft	180.37596 ft	-184.76666 psf	686.3869 psf	428.90213 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 3	-35.55 ft	179.7206 ft	-183.58842 psf	810.84854 psf	506.6744 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent

								Cohesion)
Slice 4	-32.05 ft	179.19835 ft	-181.7637 psf	866.65457 psf	541.54588 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 5	-28.908333 ft	178.86494 ft	-179.59703 psf	970.36327 psf	606.35027 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 6	-26.125 ft	178.68781 ft	-178.59656 psf	1,117.4093 psf	698.2348 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-23.341667 ft	178.6146 ft	-175.945 psf	1,226.2843 psf	766.26746 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 8	-20.558333 ft	178.64498 ft	-179.69973 psf	1,304.9008 psf	815.39252 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-17.775 ft	178.7791 ft	-188.75781 psf	1,358.9118 psf	849.14232 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-14.991667 ft	179.01751 ft	-202.18527 psf	1,392.4532 psf	870.10132 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 11	-11.937442 ft	179.40605 ft	-360.02514 psf	1,446.5051 psf	903.87668 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 12	-8.1374419 ft	180.07539 ft	-400.40609 psf	1,569.1649 psf	980.52305 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	-5.5625 ft	180.6049 ft	-361.0774 psf	1,568.3015 psf	979.98353 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	-3.84375 ft	181.0431 ft	-336.29385 psf	1,468.5305 psf	917.63971 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent

								Cohesion)
Slice 15	-1.28125 ft	181.76198 ft	-299.7325 psf	1,323.7474 psf	827.1692 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	0.6775 ft	182.36946 ft	-272.60257 psf	3,062.9853 psf	1,913.9656 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	2.9736904 ft	183.18595 ft	-242.8472 psf	2,933.2119 psf	1,832.8742 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	5.3659854 ft	184.09278 ft	-204.08884 psf	3,016.9193 psf	2,813.3227 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.58988 ft	-180.68259 psf	2,955.4642 psf	2,756.015 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.20075 ft	-159.86935 psf	2,883.3759 psf	2,688.7915 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	10.95 ft	186.66333 ft	-103.45834 psf	2,721.2616 psf	2,537.6175 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	14 ft	188.26236 ft	-70.070927 psf	2,544.5355 psf	2,372.8177 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	15.25 ft	188.97382 ft	-62.340785 psf	2,459.5919 psf	2,293.6065 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	16 ft	189.424 ft	-58.384012 psf	2,407.2906 psf	2,244.8348 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	17.50351 ft	190.36741 ft	-50.390413 psf	2,301.8296 psf	2,146.4908 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	19.25351 ft	191.51456 ft	-43.009401 psf	2,180.2859 psf	2,033.1495 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	20.75 ft	192.55706 ft	-38.324338 psf	2,069.9059 psf	1,617.1878 psf	0 psf	0 psf	Gravel Borrow
Slice 28	22.75 ft	194.051 ft	-33.503747 psf	1,815.8883 psf	1,693.3432 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	24.25 ft	195.21077 ft	-30.511031 psf	1,718.5617 psf	1,602.5848 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	25.2 ft	195.99707 ft	-29.171505 psf	1,630.1664 psf	1,520.1548 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel

Slice 31	26.25 ft	196.88485 ft	-28.172489 psf	1,534.6787 psf	1,431.111 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	27.925 ft	198.40854 ft	-28.272026 psf	1,383.1063 psf	1,289.7675 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	30.575 ft	200.97593 ft	-31.384334 psf	1,152.0352 psf	1,074.2902 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	33.9 ft	204.64532 ft	-45.385097 psf	867.58574 psf	809.0368 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	36.9 ft	208.28902 ft	-72.810031 psf	678.82745 psf	633.01684 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	38.65 ft	210.68762 ft	-107.55797 psf	539.99438 psf	503.55291 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	39.8 ft	212.37424 ft	-144.69408 psf	452.25506 psf	421.73467 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	41 ft	214.28629 ft	-201.88589 psf	367.78123 psf	342.96154 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	42.19125 ft	216.27268 ft	-285.31739 psf	289.77867 psf	270.22298 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	43.348543 ft	218.4016 ft	-399.23263 psf	202.98331 psf	189.285 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	44.913607 ft	221.54185 ft	0 psf	91.151408 psf	71.215285 psf	0 psf	0 psf	Gravel Borrow

2A.4 Global - Pseudo-Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 651
Date: 01/17/2022
Time: 02:02:35 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:10:23 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.4 Global - Pseudo-Static (M-P)

Description: Project Num: 00180-366-01 Wall: 05.85L-A Station: 1+90
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb

Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-50, 180.86613) ft
Left-Zone Right Coordinate: (0, 195) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.19

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft

Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region	SEW Wall	76,73,74,68,55,58,12,22	163.72

26			ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3928 of 16926 converged

Current Slip Surface

Slip Surface: 2,323
Factor of Safety: 1.2
Volume: 1,399.3073 ft³
Weight: 168,087.67 lbf
Resisting Moment: 9,146,728.7 lbf·ft
Activating Moment: 7,442,258.5 lbf·ft
Resisting Force: 106,365.34 lbf
Activating Force: 86,538.675 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-43.677643, 181.57994) ft
Entry: (45.712628, 223.23687) ft
Radius: 74.84631 ft
Center: (-22.766519, 253.44576) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-42.083232 ft	181.15391 ft	-184.13636 psf	122.58598 psf	76.600224 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-38.894411 ft	180.37596 ft	-184.76666 psf	323.13446 psf	201.91682 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Slice 3	-35.55 ft	179.7206 ft	-183.58842 psf	534.14846 psf	333.773 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 4	-32.05 ft	179.19835 ft	-181.7637 psf	741.94699 psf	463.61994 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 5	-28.908333 ft	178.86494 ft	-179.59703 psf	980.874 psf	612.9181 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 6	-26.125 ft	178.68781 ft	-178.59656 psf	1,244.466 psf	777.62864 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-23.341667 ft	178.6146 ft	-175.945 psf	1,466.958 psf	916.65707 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 8	-20.558333 ft	178.64498 ft	-179.69973 psf	1,635.2007 psf	1,021.7868 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-17.775 ft	178.7791 ft	-188.75781 psf	1,742.2077 psf	1,088.6522 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-14.991667 ft	179.01751 ft	-202.18527 psf	1,787.9213 psf	1,117.2172 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 11	-11.937442 ft	179.40605 ft	-360.02514 psf	1,812.6945 psf	1,132.6972 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 12	-8.1374419 ft	180.07539 ft	-400.40609 psf	1,874.0357 psf	1,171.0275 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	-5.5625 ft	180.6049 ft	-361.0774 psf	1,802.2847 psf	1,126.1925 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Slice 14	-3.84375 ft	181.0431 ft	-336.29385 psf	1,646.2977 psf	1,028.721 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	-1.28125 ft	181.76198 ft	-299.7325 psf	1,418.7764 psf	886.54988 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	0.6775 ft	182.36946 ft	-272.60257 psf	3,081.3621 psf	1,925.4487 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	2.9736904 ft	183.18595 ft	-242.8472 psf	2,872.2802 psf	1,794.7999 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	5.3659854 ft	184.09278 ft	-204.08884 psf	2,991.3639 psf	2,789.492 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.58988 ft	-180.68259 psf	2,880.9486 psf	2,686.528 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.20075 ft	-159.86935 psf	2,758.9157 psf	2,572.7305 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	10.95 ft	186.66333 ft	-103.45834 psf	2,514.3397 psf	2,344.6597 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	14 ft	188.26236 ft	-70.070927 psf	2,288.0101 psf	2,133.6039 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	15.25 ft	188.97382 ft	-62.340785 psf	2,193.4649 psf	2,045.4391 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	16 ft	189.424 ft	-58.384012 psf	2,138.6447 psf	1,994.3184 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	17.50351 ft	190.36741 ft	-50.390413 psf	2,034.4752 psf	1,897.1788 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	19.25351 ft	191.51456 ft	-43.009401 psf	1,923.2735 psf	1,793.4816 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	20.75 ft	192.55706 ft	-38.324338 psf	1,834.1667 psf	1,433.0081 psf	0 psf	0 psf	Gravel Borrow
Slice 28	22.75 ft	194.051 ft	-33.503747 psf	1,610.1985 psf	1,501.5344 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	24.25 ft	195.21077 ft	-30.511031 psf	1,539.9531 psf	1,436.0295 psf	0 psf	0 psf	ESU 4B Dense to Very Dense

								Sand/Gravel
Slice 30	25.2 ft	195.99707 ft	-29.171505 psf	1,470.7603 psf	1,371.5062 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	26.25 ft	196.88485 ft	-28.172489 psf	1,397.2738 psf	1,302.9789 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	27.925 ft	198.40854 ft	-28.272026 psf	1,283.1098 psf	1,196.5192 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	30.575 ft	200.97593 ft	-31.384334 psf	1,111.1906 psf	1,036.202 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	33.9 ft	204.64532 ft	-45.385097 psf	894.06429 psf	833.72844 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	36.9 ft	208.28902 ft	-72.810031 psf	756.51958 psf	705.46592 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	38.65 ft	210.68762 ft	-107.55797 psf	634.61828 psf	591.79112 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	39.8 ft	212.37424 ft	-144.69408 psf	552.38594 psf	515.10823 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	41 ft	214.28629 ft	-201.88589 psf	469.51281 psf	437.82778 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	42.19125 ft	216.27268 ft	-285.31739 psf	388.30696 psf	362.1021 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	43.348543 ft	218.4016 ft	-399.23263 psf	284.55685 psf	265.35356 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	44.913607 ft	221.54185 ft	0 psf	141.02731 psf	110.18261 psf	0 psf	0 psf	Gravel Borrow

2A.5 Global - Post-Seismic (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 651
Date: 01/17/2022
Time: 02:02:35 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:12:26 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.5 Global - Post-Seismic (Spencer)

Description: Project Num: 00180-366-01 Wall: 05.85L-A Station: 1+90
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

Common Borrow
- Material Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-50, 180.86613) ft
Left-Zone Right Coordinate: (0, 195) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft

Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region	SEW Wall	76,73,74,68,55,58,12,22	163.72

26			ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3713 of 16926 converged

Current Slip Surface

Slip Surface: 3,605
Factor of Safety: 1.6
Volume: 1,345.2449 ft³
Weight: 161,587.73 lbf
Resisting Moment: 8,274,980.4 lbf·ft
Activating Moment: 5,077,988.3 lbf·ft
Resisting Force: 102,599.41 lbf
Activating Force: 62,974.195 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-39.462739, 182.05582) ft
Entry: (43.844369, 223.22438) ft
Radius: 68.051682 ft
Center: (-19.83779, 247.21634) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-38.381369 ft	181.74952 ft	-184.72699 psf	84.179661 psf	52.601291 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	181.15543 ft	-184.12592 psf	231.34168 psf	144.55832 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.62304 ft	-182.80161 psf	348.37297 psf	217.68759 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice	-31.466667	180.17606	-181.52704	439.96106	274.91818			ESU 2A Very

4	ft	ft	psf	psf	psf	0 psf	0 psf	Loose to Loose Sand/Gravel
Slice 5	-28.908333 ft	179.78648 ft	-179.6421 psf	593.07459 psf	370.59414 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.125 ft	179.47013 ft	-178.87824 psf	795.0535 psf	496.80457 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-23.341667 ft	179.26921 ft	-178.19734 psf	961.48033 psf	600.79959 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-20.558333 ft	179.1827 ft	-178.33075 psf	1,097.3473 psf	685.69868 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-17.775 ft	179.21018 ft	-185.68001 psf	1,206.526 psf	753.92113 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-14.991667 ft	179.35177 ft	-198.74798 psf	1,292.0634 psf	807.37084 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-11.747559 ft	179.67303 ft	-344.90271 psf	1,407.0872 psf	879.24565 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-7.9475589 ft	180.24066 ft	-400.29183 psf	1,541.6773 psf	963.3469 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-5.5625 ft	180.68028 ft	-362.75844 psf	1,578.3879 psf	986.2862 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.84375 ft	181.08401 ft	-337.22185 psf	1,497.7687 psf	935.90976 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.28125 ft	181.75709 ft	-299.62191 psf	1,375.917 psf	859.76834 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.6775 ft	182.33452 ft	-271.81281 psf	3,332.4068 psf	2,082.3189 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	2.9086702 ft	183.09994 ft	-242.27377 psf	3,238.6145 psf	2,023.7109 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	5.3009652 ft	183.98454 ft	-201.86945 psf	3,233.626 psf	3,015.4051 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.49909 ft	-177.12016 psf	3,192.5145 psf	2,977.068 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.10525 ft	-156.36495 psf	3,143.3566 psf	2,931.2274 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	10.95 ft	186.57099 ft	-102.19168 psf	3,021.7952 psf	2,817.8697 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
								ESU 4B Dense to

Slice 22	14 ft	188.18493 ft	-68.87008 psf	2,873.5417 psf	2,679.621 psf	0 psf	0 psf	Very Dense Sand/Gravel
Slice 23	15.25 ft	188.90859 ft	-61.372977 psf	2,795.2376 psf	2,606.6012 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	16 ft	189.36879 ft	-57.617279 psf	2,745.6778 psf	2,560.3859 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	17.50351 ft	190.33736 ft	-50.046546 psf	2,643.3197 psf	2,464.9355 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	19.25351 ft	191.52011 ft	-43.065855 psf	2,521.9621 psf	2,351.7677 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	20.75 ft	192.60142 ft	-38.792586 psf	2,450.846 psf	1,914.8108 psf	0 psf	0 psf	Gravel Borrow
Slice 28	22.75 ft	194.16219 ft	-34.625819 psf	2,124.6577 psf	1,981.2753 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	24.25 ft	195.37822 ft	-32.143761 psf	2,018.3257 psf	1,882.1191 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	25.2 ft	196.20892 ft	-31.270669 psf	1,917.5968 psf	1,788.1879 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	26.25 ft	197.14917 ft	-30.956212 psf	1,807.5674 psf	1,685.5839 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	27.925 ft	198.77787 ft	-32.204416 psf	1,629.146 psf	1,519.2032 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	30.575 ft	201.54701 ft	-38.262027 psf	1,350.0783 psf	1,258.9684 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	33.9 ft	205.59165 ft	-58.81759 psf	992.03567 psf	925.08823 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	36.9 ft	209.68543 ft	-104.92924 psf	733.61111 psf	684.10343 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	38.65 ft	212.45926 ft	-167.01043 psf	548.27386 psf	511.27365 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	39.8 ft	214.44935 ft	-233.4533 psf	429.34405 psf	400.36981 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	41 ft	216.77626 ft	-345.23437 psf	311.36094 psf	290.34878 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	42.095707 ft	219.02478 ft	-491.37336 psf	211.62726 psf	197.34562 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice	42.448792	219.80479	-545.92821	198.62307	124.11347			ESU 2B Medium

40	ft	ft	psf	psf	psf	0 psf	0 psf	Dense Sand/Gravel
Slice 41	43.17527 ft	221.57977 ft	0 psf	106.26164 psf	83.020691 psf	0 psf	0 psf	Gravel Borrow

2A.6 Global - Post-Seismic (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 651
Date: 01/17/2022
Time: 02:02:35 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:12:43 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.6 Global - Post-Seismic (M-P)

Description: Project Num: 00180-366-01 Wall: 05.85L-A Station: 1+90
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-50, 180.86613) ft
Left-Zone Right Coordinate: (0, 195) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft

	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft

Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²

Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3986 of 16926 converged

Current Slip Surface

Slip Surface: 3,565
Factor of Safety: 1.6
Volume: 1,324.6782 ft³
Weight: 158,551.65 lbf
Resisting Moment: 7,224,518.2 lbf·ft
Activating Moment: 4,447,222.2 lbf·ft
Resisting Force: 99,458.321 lbf
Activating Force: 61,253.09 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-39.462739, 182.05582) ft
Entry: (40.107848, 223.2) ft
Radius: 60.629231 ft
Center: (-18.446374, 238.92599) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-38.381369 ft	181.67926 ft	-184.7297 psf	66.443221 psf	41.518332 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	180.94679 ft	-184.09026 psf	202.22966 psf	126.36712 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.28543 ft	-182.76023 psf	336.93437 psf	210.53996 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

Slice 4	-31.466667 ft	179.72338 ft	-181.47672 psf	465.23465 psf	290.71087 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-28.908333 ft	179.22293 ft	-179.60891 psf	662.84438 psf	414.19114 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.125 ft	178.80133 ft	-178.61864 psf	923.91702 psf	577.32743 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-23.341667 ft	178.51084 ft	-175.61288 psf	1,157.8436 psf	723.501 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-20.558333 ft	178.34956 ft	-180.54345 psf	1,354.3699 psf	846.30423 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-17.775 ft	178.31645 ft	-192.10306 psf	1,506.6088 psf	941.43367 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-14.991667 ft	178.41132 ft	-250.32815 psf	1,611.7546 psf	1,007.1361 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-12.700355 ft	178.57642 ft	-392.05384 psf	1,687.5171 psf	1,054.4777 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-10.350532 ft	178.85753 ft	-415.05091 psf	1,764.0149 psf	1,102.2788 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-7.4501774 ft	179.32051 ft	-369.72616 psf	1,818.5854 psf	1,136.3783 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-5.5625 ft	179.68319 ft	-340.41286 psf	1,803.6886 psf	1,127.0697 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-3.84375 ft	180.09637 ft	-314.78325 psf	1,683.7745 psf	1,052.1391 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-1.28125 ft	180.79272 ft	-277.77774 psf	1,502.4471 psf	938.83317 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	0.6775 ft	181.39625 ft	-250.59007 psf	3,402.9843 psf	2,126.4206 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	2.1603505 ft	181.91254 ft	-231.23046 psf	3,284.394 psf	2,052.3171 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	3.3828505 ft	182.36462 ft	-212.67007 psf	3,362.6885 psf	3,135.7577 psf	0 psf	0 psf	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
Slice 20	4.969795 ft	183.01554 ft	-179.14105 psf	3,252.7731 psf	3,033.26 psf	0 psf	0 psf	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
								ESU 5B Very Stiff

Slice 21	6.569795 ft	183.70034 ft	-145.27789 psf	3,142.6751 psf	2,930.592 psf	0 psf	0 psf	to Hard Silt and Clay/Dense to Very Dense Silt
Slice 22	7.1191192 ft	183.95061 ft	-136.31103 psf	3,104.158 psf	2,894.6742 psf	0 psf	0 psf	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
Slice 23	8.0691192 ft	184.41013 ft	-125.52094 psf	3,036.6881 psf	2,831.7574 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	9.925 ft	185.35712 ft	-101.58276 psf	2,906.0488 psf	2,709.9344 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	11.975 ft	186.49471 ft	-83.542116 psf	2,763.3895 psf	2,576.9024 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	14 ft	187.72311 ft	-65.252821 psf	2,610.9188 psf	2,434.7212 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	15.25 ft	188.52393 ft	-55.654776 psf	2,511.1937 psf	2,341.726 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	16 ft	189.03629 ft	-52.935826 psf	2,450.9936 psf	2,285.5885 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	17.50351 ft	190.1207 ft	-47.576163 psf	2,332.021 psf	2,174.6448 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	19.25351 ft	191.45269 ft	-42.381173 psf	2,198.6677 psf	2,050.2908 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	20.75 ft	192.68119 ft	-39.635688 psf	2,137.6769 psf	1,670.1363 psf	0 psf	0 psf	Gravel Borrow
Slice 32	22.75 ft	194.47537 ft	-37.787964 psf	1,811.0101 psf	1,688.7942 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	24.25 ft	195.88183 ft	-37.053605 psf	1,709.937 psf	1,594.542 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	25.2 ft	196.85604 ft	-37.707094 psf	1,615.7578 psf	1,506.7185 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	26.25 ft	197.96418 ft	-39.450437 psf	1,513.9555 psf	1,411.7863 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	27.925 ft	199.92134 ft	-45.186409 psf	1,348.2056 psf	1,257.222 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	30.575 ft	203.32086 ft	-62.748622 psf	1,087.0422 psf	1,013.6833 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	32.9 ft	206.74046 ft	-93.98265 psf	849.49406 psf	792.16603 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel

Slice 39	34.9 ft	210.19237 ft	-158.39432 psf	627.76051 psf	585.39614 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	36.542942 ft	213.43596 ft	-282.44568 psf	486.43747 psf	453.61028 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	37.542942 ft	215.68308 ft	-383.52709 psf	442.4543 psf	276.47613 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 42	38.084547 ft	217.01942 ft	-430.69764 psf	367.71312 psf	229.77266 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 43	38.834547 ft	219.13199 ft	-346.48104 psf	253.48764 psf	158.39666 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 44	39.753924 ft	221.98416 ft	-329.47457 psf	108.89079 psf	68.042515 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

2B.1 Global - Static FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
Time: 02:07:09 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:17:01 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.1 Global - Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

Common Borrow
- Material Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 181.99516) ft
Left-Zone Right Coordinate: (0, 196.3) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y

	9 ft	224 ft
	37.9 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft

Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
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Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
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Point 71	15.5 ft	211.7 ft
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Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft

Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²

Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3242 of 16926 converged

Current Slip Surface

Slip Surface: 1,021
Factor of Safety: 1.7
Volume: 1,418.7634 ft³
Weight: 154,405.55 lbf
Resisting Moment: 8,919,144.1 lbf·ft
Activating Moment: 5,346,275.2 lbf·ft
Resisting Force: 105,234.7 lbf
Activating Force: 63,084.426 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-38.240876, 182.19377) ft
Entry: (46.166189, 223.23991) ft
Radius: 72.22526 ft
Center: (-20.046856, 252.08988) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-37.770438 ft	182.07469 ft	-184.85613 psf	32.647615 psf	20.400494 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-35.55 ft	181.57087 ft	-183.87843 psf	158.60209 psf	99.105582 psf	0 psf	0 psf	ESU 2A Very Loose to Loose

								Sand/Gravel
Slice 3	-32.05 ft	180.89112 ft	-181.90896 psf	312.02985 psf	194.97789 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-28.908333 ft	180.42402 ft	-179.6982 psf	487.91756 psf	304.88473 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-26.125 ft	180.13438 ft	-179.0209 psf	691.45366 psf	432.0682 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-23.341667 ft	179.95326 ft	-180.28457 psf	861.1649 psf	538.11555 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-20.558333 ft	179.87984 ft	-178.0415 psf	1,001.5771 psf	625.85485 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-17.775 ft	179.91379 ft	-180.73923 psf	1,116.2529 psf	697.51225 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.991667 ft	180.05526 ft	-190.1224 psf	1,208.0335 psf	754.86312 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.326997 ft	180.28979 ft	-254.29877 psf	1,307.044 psf	816.73175 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-9.780992 ft	180.60949 ft	-368.84527 psf	1,413.6703 psf	883.35927 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-7.2539947 ft	181.01803 ft	-403.69014 psf	1,501.3089 psf	938.12194 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-5.5625 ft	181.33331 ft	-377.40593 psf	1,520.8509 psf	950.33311 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.84375 ft	181.71788 ft	-351.63392 psf	1,444.7217 psf	902.76229 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.28125 ft	182.35768 ft	-313.21625 psf	1,329.5116 psf	830.77108 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.6775 ft	182.90542 ft	-284.61599 psf	3,318.5771 psf	2,073.6771 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	3.3141258 ft	183.77835 ft	-248.89977 psf	3,119.0069 psf	1,948.9718 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	5.7064208 ft	184.61365 ft	-212.44256 psf	3,013.5322 psf	2,810.1642 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.94952 ft	-194.40709 psf	2,947.8517 psf	2,748.9162 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice	7.95 ft	185.5196	-171.22478	4,104.4667	3,827.4771	0 psf	0 psf	ESU 4B Dense to Very Dense

20		ft	psf	psf	psf			Sand/Gravel
Slice 21	8.95 ft	185.94105 ft	-152.7832 psf	4,008.0903 psf	3,737.6047 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	11 ft	186.9157 ft	-105.78401 psf	4,010.2923 psf	3,739.658 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	14 ft	188.40304 ft	-72.253284 psf	3,698.7316 psf	3,449.123 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	15.25 ft	189.07767 ft	-63.880304 psf	2,480.6563 psf	2,313.2495 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	16 ft	189.5057 ft	-59.51264 psf	2,408.0477 psf	2,245.5408 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	17.50351 ft	190.40457 ft	-50.815986 psf	2,262.1644 psf	2,109.5025 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	19.25351 ft	191.49963 ft	-42.857717 psf	2,094.2702 psf	1,952.9385 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	20.75 ft	192.49727 ft	-37.69367 psf	1,970.8238 psf	1,539.7763 psf	0 psf	0 psf	Gravel Borrow
Slice 29	22.75 ft	193.93054 ft	-32.288402 psf	1,679.1011 psf	1,565.7871 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	24.25 ft	195.04449 ft	-28.88961 psf	1,630.2693 psf	1,520.2508 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	25.2 ft	195.80131 ft	-27.371515 psf	1,597.0866 psf	1,489.3073 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	26.25 ft	196.6563 ft	-26.087373 psf	1,559.1239 psf	1,453.9065 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	27.925 ft	198.1265 ft	-25.620539 psf	1,481.4122 psf	1,381.4392 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	30.575 ft	200.60723 ft	-27.532663 psf	1,347.6559 psf	1,256.7095 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	33.4 ft	203.56213 ft	-35.750746 psf	1,369.741 psf	1,277.3041 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	36.4 ft	207.096 ft	-57.336715 psf	1,053.7077 psf	982.59829 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	39.05 ft	210.61649 ft	-100.14726 psf	780.76011 psf	728.07058 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	41 ft	213.52142 ft	-170.16956 psf	595.0236 psf	554.86849 psf	0 psf	0 psf	ESU 4B Dense to Very Dense

								Sand/Gravel
Slice 39	42.19125 ft	215.45231 ft	-237.66118 psf	489.20603 psf	456.192 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	43.581761 ft	217.98102 ft	-363.35006 psf	342.19412 psf	319.10118 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	45.373605 ft	221.54251 ft	0 psf	163.05805 psf	127.39491 psf	0 psf	0 psf	Gravel Borrow

2B.2 Global - Static FC Wall (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
Time: 02:07:09 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:24:47 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.2 Global - Static FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 181.99516) ft
Left-Zone Right Coordinate: (0, 196.3) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	37.9 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft

Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft

Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region			7.7095

23	Gravel Borrow	49,75,81,80	ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3668 of 16926 converged

Current Slip Surface

Slip Surface: 1,021
Factor of Safety: 1.7
Volume: 1,418.7634 ft³
Weight: 154,405.55 lbf
Resisting Moment: 8,893,411.3 lbf·ft
Activating Moment: 5,346,275.2 lbf·ft
Resisting Force: 104,794.33 lbf
Activating Force: 63,006.121 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-38.240876, 182.19377) ft
Entry: (46.166189, 223.23991) ft
Radius: 72.22526 ft
Center: (-20.046856, 252.08988) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-37.770438 ft	182.07469 ft	-184.85613 psf	21.278947 psf	13.296562 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

Slice 2	-35.55 ft	181.57087 ft	-183.87843 psf	113.91874 psf	71.184327 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-32.05 ft	180.89112 ft	-181.90896 psf	253.64302 psf	158.49375 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-28.908333 ft	180.42402 ft	-179.6982 psf	433.13249 psf	270.65122 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-26.125 ft	180.13438 ft	-179.0209 psf	653.07406 psf	408.08597 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-23.341667 ft	179.95326 ft	-180.28457 psf	858.10305 psf	536.20229 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-20.558333 ft	179.87984 ft	-178.0415 psf	1,040.7677 psf	650.34386 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-17.775 ft	179.91379 ft	-180.73923 psf	1,195.027 psf	746.73575 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.991667 ft	180.05526 ft	-190.1224 psf	1,316.9287 psf	822.90837 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.326997 ft	180.28979 ft	-254.29877 psf	1,432.8859 psf	895.36647 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-9.780992 ft	180.60949 ft	-368.84527 psf	1,544.3928 psf	965.04376 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-7.2539947 ft	181.01803 ft	-403.69014 psf	1,625.7153 psf	1,015.8597 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-5.5625 ft	181.33331 ft	-377.40593 psf	1,634.9553 psf	1,021.6335 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.84375 ft	181.71788 ft	-351.63392 psf	1,541.8019 psf	963.42476 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.28125 ft	182.35768 ft	-313.21625 psf	1,397.1193 psf	873.01701 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.6775 ft	182.90542 ft	-284.61599 psf	3,384.6638 psf	2,114.9727 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	3.3141258 ft	183.77835 ft	-248.89977 psf	3,139.6029 psf	1,961.8416 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	5.7064208 ft	184.61365 ft	-212.44256 psf	3,071.487 psf	2,864.208 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.94952 ft	-194.40709 psf	2,987.2701 psf	2,785.6745 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel

Slice 20	7.95 ft	185.5196 ft	-171.22478 psf	4,136.6538 psf	3,857.4921 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	8.95 ft	185.94105 ft	-152.7832 psf	4,015.1596 psf	3,744.1969 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	11 ft	186.9157 ft	-105.78401 psf	3,971.5313 psf	3,703.5128 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	14 ft	188.40304 ft	-72.253284 psf	3,601.834 psf	3,358.7645 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	15.25 ft	189.07767 ft	-63.880304 psf	2,365.6407 psf	2,205.9956 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	16 ft	189.5057 ft	-59.51264 psf	2,285.2301 psf	2,131.0116 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	17.50351 ft	190.40457 ft	-50.815986 psf	2,127.174 psf	1,983.6218 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	19.25351 ft	191.49963 ft	-42.857717 psf	1,950.3184 psf	1,818.7013 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	20.75 ft	192.49727 ft	-37.69367 psf	1,820.6147 psf	1,422.4201 psf	0 psf	0 psf	Gravel Borrow
Slice 29	22.75 ft	193.93054 ft	-32.288402 psf	1,536.6102 psf	1,432.9122 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	24.25 ft	195.04449 ft	-28.88961 psf	1,492.612 psf	1,391.8832 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	25.2 ft	195.80131 ft	-27.371515 psf	1,464.9356 psf	1,366.0745 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	26.25 ft	196.6563 ft	-26.087373 psf	1,434.5725 psf	1,337.7605 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	27.925 ft	198.1265 ft	-25.620539 psf	1,373.2823 psf	1,280.6065 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	30.575 ft	200.60723 ft	-27.532663 psf	1,272.7873 psf	1,186.8934 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	33.4 ft	203.56213 ft	-35.750746 psf	1,352.7872 psf	1,261.4945 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	36.4 ft	207.096 ft	-57.336715 psf	1,086.0017 psf	1,012.7129 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	39.05 ft	210.61649 ft	-100.14726 psf	847.394 psf	790.20769 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
								ESU 4B Dense to

Slice 38	41 ft	213.52142 ft	-170.16956 psf	678.63253 psf	632.83507 psf	0 psf	0 psf	Very Dense Sand/Gravel
Slice 39	42.19125 ft	215.45231 ft	-237.66118 psf	578.69343 psf	539.64035 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	43.581761 ft	217.98102 ft	-363.35006 psf	423.9667 psf	395.35535 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	45.373605 ft	221.54251 ft	0 psf	226.88037 psf	177.25837 psf	0 psf	0 psf	Gravel Borrow

2B.3 Global - Pseudo-Static FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
Time: 02:07:09 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:32:27 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.3 Global - Pseudo-Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

Common Borrow
- Material Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

SEW Wall
- Material Model: High Strength
- Unit Weight: 130 pcf

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 100 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

Gravel Borrow
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf

Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 181.99516) ft
Left-Zone Right Coordinate: (0, 196.3) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.191

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf

Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft

Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft

Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²

Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 2154 of 16926 converged

Current Slip Surface

Slip Surface: 1,021
Factor of Safety: 1.3
Volume: 1,418.8147 ft³
Weight: 154,412.22 lbf
Resisting Moment: 8,436,684.9 lbf·ft
Activating Moment: 6,572,450.7 lbf·ft
Resisting Force: 102,643.9 lbf
Activating Force: 79,937.615 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-38.240876, 182.19377) ft
Entry: (46.166189, 223.23991) ft
Radius: 72.22526 ft
Center: (-20.046856, 252.08988) ft

Slip Slices

	X	Y	PWP	Base Normal	Frictional	Cohesive	Suction	Base Material

				Stress	Strength	Strength	Strength	
Slice 1	-37.770438 ft	182.07469 ft	-184.85613 psf	368.2252 psf	230.09264 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-35.55 ft	181.57087 ft	-183.87843 psf	527.83809 psf	329.82984 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 3	-32.05 ft	180.89112 ft	-181.90896 psf	673.93747 psf	421.12287 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 4	-28.908333 ft	180.42402 ft	-179.6982 psf	841.24531 psf	525.66841 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 5	-26.125 ft	180.13438 ft	-179.0209 psf	1,036.5562 psf	647.71221 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 6	-23.341667 ft	179.95326 ft	-180.28457 psf	1,175.074 psf	734.26774 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-20.558333 ft	179.87984 ft	-178.0415 psf	1,271.8969 psf	794.76937 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 8	-17.775 ft	179.91379 ft	-180.73923 psf	1,337.0153 psf	835.45987 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-14.991667 ft	180.05526 ft	-190.1224 psf	1,377.2287 psf	860.58801 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-12.326997 ft	180.28979 ft	-254.29877 psf	1,428.2837 psf	892.49071 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 11	-9.780992 ft	180.60949 ft	-368.84527 psf	1,489.1459 psf	930.52164 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

								(Apparent Cohesion)
Slice 12	-7.2539947 ft	181.01803 ft	-403.69014 psf	1,593.2967 psf	995.60225 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	-5.5625 ft	181.33331 ft	-377.40593 psf	1,579.1228 psf	986.74544 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	-3.84375 ft	181.71788 ft	-351.63392 psf	1,475.1626 psf	921.78389 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	-1.28125 ft	182.35768 ft	-313.21625 psf	1,325.9764 psf	828.562 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	0.6775 ft	182.90542 ft	-284.61599 psf	3,110.6219 psf	1,943.7323 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	3.3141258 ft	183.77835 ft	-248.89977 psf	2,859.1394 psf	1,786.5886 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	5.7064208 ft	184.61365 ft	-212.44256 psf	2,873.9393 psf	2,679.9918 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.94952 ft	-194.40709 psf	2,785.7289 psf	2,597.7342 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.5196 ft	-171.22478 psf	3,823.9648 psf	3,565.9049 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	8.95 ft	185.94105 ft	-152.7832 psf	3,697.1477 psf	3,447.646 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	11 ft	186.9157 ft	-105.78401 psf	3,548.9342 psf	3,309.4347 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	14 ft	188.40304 ft	-72.253284 psf	3,179.0081 psf	2,964.473 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	15.25 ft	189.07767 ft	-63.880304 psf	2,084.4722 psf	1,943.8018 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice		189.5057	-59.51264	2,008.2702	1,872.7422			ESU 4B Dense to

25	16 ft	ft	psf	psf	psf	0 psf	0 psf	Very Dense Sand/Gravel
Slice 26	17.50351 ft	190.40457 ft	-50.815986 psf	1,858.3737 psf	1,732.9615 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	19.25351 ft	191.49963 ft	-42.857717 psf	1,690.6431 psf	1,576.5502 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	20.75 ft	192.49727 ft	-37.69367 psf	1,531.4311 psf	1,196.4851 psf	0 psf	0 psf	Gravel Borrow
Slice 29	22.75 ft	193.93054 ft	-32.288402 psf	1,304.9752 psf	1,216.9091 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	24.25 ft	195.04449 ft	-28.88961 psf	1,250.7663 psf	1,166.3585 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	25.2 ft	195.80131 ft	-27.371515 psf	1,215.2304 psf	1,133.2207 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	25.95 ft	196.40529 ft	-26.439209 psf	1,187.7917 psf	1,107.6337 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	26.3 ft	196.6976 ft	-26.013331 psf	1,174.2929 psf	1,095.0458 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	27.925 ft	198.1265 ft	-25.620539 psf	1,103.736 psf	1,029.2505 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	30.575 ft	200.60723 ft	-27.532663 psf	984.229 psf	917.80839 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	33.4 ft	203.56213 ft	-35.750746 psf	985.14407 psf	918.66171 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	36.4 ft	207.096 ft	-57.336715 psf	735.49241 psf	685.85777 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	38.65 ft	210.02434 ft	-90.418054 psf	560.18954 psf	522.3852 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	39.8 ft	211.66302 ft	-120.70681 psf	473.84035 psf	441.86328 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	41 ft	213.52142 ft	-170.16956 psf	390.78162 psf	364.40975 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	42.19125 ft	215.45231 ft	-237.66118 psf	314.14137 psf	292.94156 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 42	43.581761 ft	217.98102 ft	-363.35006 psf	210.48732 psf	196.2826 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 43	45.373605 ft	221.54251 ft	0 psf	86.935972 psf	67.921825 psf	0 psf	0 psf	Gravel Borrow

2B.4 Global - Pseudo-Static FC Walll (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
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Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:21:21 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.4 Global - Pseudo-Static FC Walll (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb

Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 181.99516) ft
Left-Zone Right Coordinate: (0, 196.3) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.191

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft

Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft

Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region	SEW Wall	72,76,22,13	11.692

19			ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3622 of 16926 converged

Current Slip Surface

Slip Surface: 1,021
Factor of Safety: 1.3
Volume: 1,418.8147 ft³
Weight: 154,412.22 lbf
Resisting Moment: 8,351,757.2 lbf·ft
Activating Moment: 6,572,450.7 lbf·ft
Resisting Force: 101,586.31 lbf
Activating Force: 79,948.783 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-38.240876, 182.19377) ft
Entry: (46.166189, 223.23991) ft
Radius: 72.22526 ft
Center: (-20.046856, 252.08988) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-37.770438 ft	182.07469 ft	-184.85613 psf	49.186123 psf	30.734901 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-35.55 ft	181.57087 ft	-183.87843 psf	168.26683 psf	105.14478 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 3	-32.05 ft	180.89112 ft	-181.90896 psf	364.95917 psf	228.0518 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 4	-28.908333 ft	180.42402 ft	-179.6982 psf	617.05079 psf	385.57613 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 5	-26.125 ft	180.13438 ft	-179.0209 psf	918.8684 psf	574.1727 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 6	-23.341667 ft	179.95326 ft	-180.28457 psf	1,205.2862 psf	753.14641 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-20.558333 ft	179.87984 ft	-178.0415 psf	1,453.7439 psf	908.39999 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 8	-17.775 ft	179.91379 ft	-180.73923 psf	1,644.5562 psf	1,027.6327 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-14.991667 ft	180.05526 ft	-190.1224 psf	1,765.4905 psf	1,103.2009 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-12.326997 ft	180.28979 ft	-254.29877 psf	1,845.9991 psf	1,153.5083 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Slice 11	-9.780992 ft	180.60949 ft	-368.84527 psf	1,893.909 psf	1,183.4457 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 12	-7.2539947 ft	181.01803 ft	-403.69014 psf	1,972.5688 psf	1,232.5978 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	-5.5625 ft	181.33331 ft	-377.40593 psf	1,917.4595 psf	1,198.1617 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	-3.84375 ft	181.71788 ft	-351.63392 psf	1,758.2033 psf	1,098.6473 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	-1.28125 ft	182.35768 ft	-313.21625 psf	1,520.192 psf	949.9214 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	0.6775 ft	182.90542 ft	-284.61599 psf	3,225.7503 psf	2,015.6725 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	3.3141258 ft	183.77835 ft	-248.89977 psf	2,864.4527 psf	1,789.9087 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	5.7064208 ft	184.61365 ft	-212.44256 psf	2,926.828 psf	2,729.3113 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.94952 ft	-194.40709 psf	2,794.2249 psf	2,605.6569 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.5196 ft	-171.22478 psf	3,790.252 psf	3,534.4672 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	8.95 ft	185.94105 ft	-152.7832 psf	3,613.2766 psf	3,369.4349 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	11 ft	186.9157 ft	-105.78401 psf	3,387.812 psf	3,159.1858 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	14 ft	188.40304 ft	-72.253284 psf	2,936.5307 psf	2,738.3592 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice		189.07767	-63.880304	1,834.5576	1,710.7527			ESU 4B Dense to

24	15.25 ft	ft	psf	psf	psf	0 psf	0 psf	Very Dense Sand/Gravel
Slice 25	16 ft	189.5057 ft	-59.51264 psf	1,751.4628 psf	1,633.2655 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	17.50351 ft	190.40457 ft	-50.815986 psf	1,594.4673 psf	1,486.8648 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	19.25351 ft	191.49963 ft	-42.857717 psf	1,427.4886 psf	1,331.1546 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	20.75 ft	192.49727 ft	-37.69367 psf	1,277.6965 psf	998.24588 psf	0 psf	0 psf	Gravel Borrow
Slice 29	22.75 ft	193.93054 ft	-32.288402 psf	1,071.0607 psf	998.78023 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	24.25 ft	195.04449 ft	-28.88961 psf	1,034.2335 psf	964.43833 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	25.2 ft	195.80131 ft	-27.371515 psf	1,012.9065 psf	944.55061 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	25.95 ft	196.40529 ft	-26.439209 psf	997.58492 psf	930.26299 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	26.3 ft	196.6976 ft	-26.013331 psf	990.25308 psf	923.42594 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	27.925 ft	198.1265 ft	-25.620539 psf	951.32339 psf	887.12341 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	30.575 ft	200.60723 ft	-27.532663 psf	889.45245 psf	829.42783 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	33.4 ft	203.56213 ft	-35.750746 psf	981.34156 psf	915.11581 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	36.4 ft	207.096 ft	-57.336715 psf	795.97929 psf	742.2627 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	38.65 ft	210.02434 ft	-90.418054 psf	654.49593 psf	610.32733 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	39.8 ft	211.66302 ft	-120.70681 psf	578.6092 psf	539.56181 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	41 ft	213.52142 ft	-170.16956 psf	502.2 psf	468.30907 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	42.19125 ft	215.45231 ft	-237.66118 psf	427.066 psf	398.24549 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice	43.581761	217.98102	-363.35006	304.81326	284.24296	0 psf	0 psf	ESU 4B Dense to Very Dense

42	ft	ft	psf	psf	psf			Sand/Gravel
Slice 43	45.373605 ft	221.54251 ft	0 psf	141.84265 psf	110.81962 psf	0 psf	0 psf	Gravel Borrow

2B.5 Global - Post-Seismic FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
Time: 02:07:09 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:26:28 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.5 Global - Post-Seismic FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

Common Borrow
- Material Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 181.99516) ft
Left-Zone Right Coordinate: (0, 196.3) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft

Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft

Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region	SEW Wall	72,76,22,13	11.692

19			ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3261 of 16926 converged

Current Slip Surface

Slip Surface: 1,021
Factor of Safety: 1.7
Volume: 1,418.8147 ft³
Weight: 154,412.22 lbf
Resisting Moment: 8,641,474.2 lbf·ft
Activating Moment: 5,105,467.4 lbf·ft
Resisting Force: 102,360.4 lbf
Activating Force: 60,480.068 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-38.240876, 182.19377) ft
Entry: (46.166189, 223.23991) ft
Radius: 72.22526 ft
Center: (-20.046856, 252.08988) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-37.770438 ft	182.07469 ft	-184.85613 psf	32.144229 psf	20.085944 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-35.55 ft	181.57087 ft	-183.87843 psf	156.37913 psf	97.716526 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-32.05 ft	180.89112 ft	-181.90896 psf	308.26356 psf	192.62445 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-28.908333 ft	180.42402 ft	-179.6982 psf	482.76859 psf	301.6673 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-26.125 ft	180.13438 ft	-179.0209 psf	684.98481 psf	428.02601 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-23.341667 ft	179.95326 ft	-180.28457 psf	854.04199 psf	533.66466 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-20.558333 ft	179.87984 ft	-178.0415 psf	994.28379 psf	621.29747 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-17.775 ft	179.91379 ft	-180.73923 psf	1,109.1401 psf	693.06764 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.991667 ft	180.05526 ft	-190.1224 psf	1,201.3536 psf	750.68907 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.326997 ft	180.28979 ft	-254.29877 psf	1,300.8011 psf	812.83073 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-9.780992 ft	180.60949 ft	-368.84527 psf	1,407.8766 psf	879.73894 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-7.2539947 ft	181.01803 ft	-403.69014 psf	1,496.1144 psf	934.87606 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-5.5625 ft	181.33331 ft	-377.40593 psf	1,516.2124 psf	947.43468 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.84375 ft	181.71788 ft	-351.63392 psf	1,440.9011 psf	900.37493 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.28125 ft	182.35768 ft	-313.21625 psf	1,326.7714 psf	829.0588 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.6775 ft	182.90542 ft	-284.61599 psf	3,313.168 psf	2,070.2972 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice	3.3141258	183.77835	-248.89977	3,115.6891	1,946.8986			ESU 2B Medium

17	ft	ft	psf	psf	psf	0 psf	0 psf	Dense Sand/Gravel
Slice 18	5.7064208 ft	184.61365 ft	-212.44256 psf	3,006.8752 psf	2,803.9564 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.94952 ft	-194.40709 psf	2,942.0427 psf	2,743.4992 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.5196 ft	-171.22478 psf	4,097.9205 psf	3,821.3727 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	8.95 ft	185.94105 ft	-152.7832 psf	4,002.7668 psf	3,732.6405 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	11 ft	186.9157 ft	-105.78401 psf	3,902.2017 psf	3,638.8619 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	14 ft	188.40304 ft	-72.253284 psf	3,594.7197 psf	3,352.1303 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	15.25 ft	189.07767 ft	-63.880304 psf	2,377.9467 psf	2,217.4712 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	16 ft	189.5057 ft	-59.51264 psf	2,306.0971 psf	2,150.4703 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	17.50351 ft	190.40457 ft	-50.815986 psf	2,161.709 psf	2,015.8263 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	19.25351 ft	191.49963 ft	-42.857717 psf	1,995.4988 psf	1,860.8327 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	20.75 ft	192.49727 ft	-37.69367 psf	1,873.1465 psf	1,463.4624 psf	0 psf	0 psf	Gravel Borrow
Slice 29	22.75 ft	193.93054 ft	-32.288402 psf	1,583.4613 psf	1,476.6015 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	24.25 ft	195.04449 ft	-28.88961 psf	1,536.211 psf	1,432.5399 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	25.2 ft	195.80131 ft	-27.371515 psf	1,504.0815 psf	1,402.5787 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	25.95 ft	196.40529 ft	-26.439209 psf	1,478.9735 psf	1,379.1651 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	26.3 ft	196.6976 ft	-26.013331 psf	1,466.2908 psf	1,367.3383 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	27.925 ft	198.1265 ft	-25.620539 psf	1,396.2447 psf	1,302.0193 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice	30.575 ft	200.60723	-27.532663	1,271.3916	1,185.5918	0 psf	0 psf	ESU 4B Dense to Very Dense

35		ft	psf	psf	psf			Sand/Gravel
Slice 36	33.4 ft	203.56213 ft	-35.750746 psf	1,303.3226 psf	1,215.368 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	36.4 ft	207.096 ft	-57.336715 psf	995.67217 psf	928.47932 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	38.65 ft	210.02434 ft	-90.418054 psf	771.12425 psf	719.085 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	39.8 ft	211.66302 ft	-120.70681 psf	657.64023 psf	613.25944 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	41 ft	213.52142 ft	-170.16956 psf	547.08975 psf	510.16945 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	42.19125 ft	215.45231 ft	-237.66118 psf	443.27672 psf	413.36223 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 42	43.581761 ft	217.98102 ft	-363.35006 psf	298.61682 psf	278.46469 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 43	45.373605 ft	221.54251 ft	0 psf	120.72592 psf	94.321427 psf	0 psf	0 psf	Gravel Borrow

2B.6 Global - Post-Seismic FC Wall (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
Time: 02:07:09 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:25:15 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.6 Global - Post-Seismic FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 2. Steady State (Global)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 2. Steady State (Global) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 181.99516) ft
Left-Zone Right Coordinate: (0, 196.3) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (70, 223.39933) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft

Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft

Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	SEW Wall	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region	ESU 4B Dense to Very Dense		

18	Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	SEW Wall	72,76,22,13	11.692 ft²
Region 20	SEW Wall	70,72,13	2.9375 ft²
Region 21	SEW Wall	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	SEW Wall	49,76,72,75	4.002 ft²
Region 25	SEW Wall	73,76,49	0.43333 ft²
Region 26	SEW Wall	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 3665 of 16926 converged

Current Slip Surface

Slip Surface: 1,021
Factor of Safety: 1.7
Volume: 1,418.8147 ft³
Weight: 154,412.22 lbf
Resisting Moment: 8,617,457.5 lbf·ft
Activating Moment: 5,105,467.4 lbf·ft
Resisting Force: 101,951.55 lbf
Activating Force: 60,409.582 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-38.240876, 182.19377) ft
Entry: (46.166189, 223.23991) ft
Radius: 72.22526 ft

Center: (-20.046856, 252.08988) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-37.770438 ft	182.07469 ft	-184.85613 psf	21.235998 psf	13.269724 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-35.55 ft	181.57087 ft	-183.87843 psf	113.49 psf	70.916425 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-32.05 ft	180.89112 ft	-181.90896 psf	252.14037 psf	157.55479 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-28.908333 ft	180.42402 ft	-179.6982 psf	429.91684 psf	268.64186 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-26.125 ft	180.13438 ft	-179.0209 psf	647.57948 psf	404.65257 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-23.341667 ft	179.95326 ft	-180.28457 psf	850.16156 psf	531.2399 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-20.558333 ft	179.87984 ft	-178.0415 psf	1,030.5615 psf	643.96629 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-17.775 ft	179.91379 ft	-180.73923 psf	1,183.0556 psf	739.25519 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.991667 ft	180.05526 ft	-190.1224 psf	1,303.9219 psf	814.78086 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.326997 ft	180.28979 ft	-254.29877 psf	1,419.4794 psf	886.9892 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-9.780992 ft	180.60949 ft	-368.84527 psf	1,531.1769 psf	956.78553 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-7.2539947 ft	181.01803 ft	-403.69014 psf	1,613.3893 psf	1,008.1575 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-5.5625 ft	181.33331 ft	-377.40593 psf	1,623.691 psf	1,014.5948 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.84375 ft	181.71788 ft	-351.63392 psf	1,532.2438 psf	957.45219 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.28125 ft	182.35768 ft	-313.21625 psf	1,390.1552 psf	868.66536 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.6775 ft	182.90542 ft	-284.61599 psf	3,373.7822 psf	2,108.1731 psf	0 psf	0 psf	ESU 2B Medium Dense

								Sand/Gravel
Slice 17	3.3141258 ft	183.77835 ft	-248.89977 psf	3,133.1456 psf	1,957.8067 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	5.7064208 ft	184.61365 ft	-212.44256 psf	3,059.2962 psf	2,852.8399 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 19	6.569795 ft	184.94952 ft	-194.40709 psf	2,977.0591 psf	2,776.1526 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 20	7.95 ft	185.5196 ft	-171.22478 psf	4,125.3393 psf	3,846.9412 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	8.95 ft	185.94105 ft	-152.7832 psf	4,006.651 psf	3,736.2625 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 22	11 ft	186.9157 ft	-105.78401 psf	3,862.4923 psf	3,601.8323 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 23	14 ft	188.40304 ft	-72.253284 psf	3,502.0013 psf	3,265.669 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 24	15.25 ft	189.07767 ft	-63.880304 psf	2,269.5402 psf	2,116.3804 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 25	16 ft	189.5057 ft	-59.51264 psf	2,190.7231 psf	2,042.8823 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 26	17.50351 ft	190.40457 ft	-50.815986 psf	2,035.6018 psf	1,898.2294 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	19.25351 ft	191.49963 ft	-42.857717 psf	1,861.73 psf	1,736.0913 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	20.75 ft	192.49727 ft	-37.69367 psf	1,734.3521 psf	1,355.0244 psf	0 psf	0 psf	Gravel Borrow
Slice 29	22.75 ft	193.93054 ft	-32.288402 psf	1,452.1565 psf	1,354.1578 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	24.25 ft	195.04449 ft	-28.88961 psf	1,409.7894 psf	1,314.6499 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	25.2 ft	195.80131 ft	-27.371515 psf	1,383.0118 psf	1,289.6793 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	25.95 ft	196.40529 ft	-26.439209 psf	1,362.8862 psf	1,270.9119 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	26.3 ft	196.6976 ft	-26.013331 psf	1,352.9229 psf	1,261.621 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	27.925 ft	198.1265 ft	-25.620539 psf	1,298.1662 psf	1,210.5596 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel

Slice 35	30.575 ft	200.60723 ft	-27.532663 psf	1,204.8632 psf	1,123.5531 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	33.4 ft	203.56213 ft	-35.750746 psf	1,292.3702 psf	1,205.1547 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	36.4 ft	207.096 ft	-57.336715 psf	1,030.4465 psf	960.90691 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	38.65 ft	210.02434 ft	-90.418054 psf	833.05742 psf	776.83861 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	39.8 ft	211.66302 ft	-120.70681 psf	729.37405 psf	680.15231 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	41 ft	213.52142 ft	-170.16956 psf	626.26025 psf	583.99713 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	42.19125 ft	215.45231 ft	-237.66118 psf	526.13212 psf	490.62614 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 42	43.581761 ft	217.98102 ft	-363.35006 psf	370.90105 psf	345.87083 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 43	45.373605 ft	221.54251 ft	0 psf	167.80031 psf	131.09997 psf	0 psf	0 psf	Gravel Borrow

2A.1 Global - Static (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 318
Date: 01/13/2022
Time: 03:58:28 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/13/2022
Last Solved Time: 04:01:16 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.1 Global - Static (Spencer)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf

Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (20.000001, 228.81169) ft
Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	43 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft

Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft
Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft
Point 40	1.5 ft	219.4 ft
Point 41	31.5 ft	233.5 ft
Point 42	6.1 ft	233.5 ft
Point 43	14.1 ft	233.5 ft
Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft
Point 54	39 ft	233.5 ft
Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area

Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Common Borrow	45,44,46,47	35.36 ft²
Region 8	Common Borrow	36,55,51,35,38,37	75.79 ft²
Region 9		43,53,46,39	58.52 ft²
Region 10		43,42,52,53	12 ft²
Region 11	Common Borrow	47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²
Region 15		47,46,53,52	65.44 ft²
Region 16	Common Borrow	41,39,46,44,33,51,55,54	171.02 ft²
Region 17	Common Borrow	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 1551 of 11466 converged

Current Slip Surface

Slip Surface: 2,555
Factor of Safety: 1.4
Volume: 1,414.2092 ft³
Weight: 173,720.13 lbf
Resisting Moment: 7,586,863.7 lbf·ft
Activating Moment: 5,287,280.8 lbf·ft
Resisting Force: 97,275.564 lbf
Activating Force: 67,817.027 lbf
Slip Rank: 1 of 11,466 slip surfaces

Exit: (-32.72383, 192.9891) ft
Entry: (50.251608, 233.58018) ft
Radius: 67.426709 ft
Center: (-12.822974, 257.41205) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-32.411915 ft	192.89439 ft	-578.06471 psf	35.98996 psf	24.275535 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 2	-30.816667 ft	192.44425 ft	-527.22959 psf	168.3422 psf	113.54825 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 3	-28.25 ft	191.78713 ft	-449.62762 psf	330.05236 psf	222.62313 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-25.683333 ft	191.23605 ft	-378.64246 psf	449.61168 psf	303.26691 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-22.75 ft	190.74097 ft	-305.92389 psf	625.52938 psf	421.92489 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-19.7 ft	190.35173 ft	-238.14544 psf	796.52858 psf	537.26531 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-17.05 ft	190.12963 ft	-186.50044 psf	884.36335 psf	596.51061 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-14.55 ft	190.01906 ft	-143.95418 psf	946.55184 psf	638.45728 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 9	-12.05 ft	190.00136 ft	-107.20267 psf	989.48396 psf	667.41536 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 10	-9.325 ft	190.09234 ft	-74.024233 psf	1,074.0601 psf	724.4627 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-6.375 ft	190.31072 ft	-45.587566 psf	1,190.8689 psf	803.25119 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-4.5 ft	190.50221 ft	-30.801475 psf	1,224.4038 psf	825.87082 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-3.2452353 ft	190.67464 ft	-23.366998 psf	1,172.741 psf	791.02376 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-1.6452353 ft	190.92259 ft	-15.459087 psf	1,106.1046 psf	746.07699 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	0.3 ft	191.28602 ft	-9.7119652 psf	3,728.8637 psf	2,515.1503 psf	0 psf	0 psf	ESU 2B Medium Dense

								Sand/Gravel
Slice 16	2.65 ft	191.79534 ft	-7.1540667 psf	3,606.2622 psf	2,432.4546 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	4.95 ft	192.38082 ft	-10.078507 psf	3,551.2911 psf	2,395.3761 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	7.35 ft	193.08713 ft	-19.081688 psf	3,485.4792 psf	2,350.9854 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	9.85 ft	193.92555 ft	-34.867853 psf	3,408.1309 psf	2,298.8133 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	11.4 ft	194.48745 ft	-47.280731 psf	3,356.4002 psf	2,263.9205 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	12.9 ft	195.09829 ft	-66.352671 psf	3,299.4711 psf	2,225.5214 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	14.85 ft	195.93123 ft	-94.504091 psf	3,220.6856 psf	2,172.3799 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	16.3825 ft	196.64489 ft	-120.31334 psf	3,148.7949 psf	2,460.1082 psf	0 psf	0 psf	Gravel Borrow
Slice 24	18.3225 ft	197.62395 ft	-152.2424 psf	2,870.5167 psf	1,936.1879 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	20.6375 ft	198.88872 ft	-191.95627 psf	2,753.5574 psf	1,857.2979 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 26	22.9525 ft	200.27527 ft	-239.26898 psf	2,628.0994 psf	1,772.6754 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 27	25.305 ft	201.81961 ft	-287.84498 psf	2,491.6453 psf	1,680.636 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 28	28 ft	203.78098 ft	-346.66576 psf	2,322.9323 psf	1,566.8376 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 29	29.51 ft	204.93081 ft	-382.79865 psf	2,226.4936 psf	1,501.7889 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 30	30.51 ft	205.76958 ft	-411.42266 psf	2,120.1432 psf	1,430.0546 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 31	31.865 ft	206.92335 ft	-451.28187 psf	1,978.975 psf	1,334.8355 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 32	33.4475 ft	208.39572 ft	-503.95806 psf	1,809.6168 psf	1,220.602 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	35.8825 ft	210.81767 ft	-594.00316 psf	1,550.9471 psf	1,046.1271 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 34	38.05 ft	213.18304 ft	-687.22762 psf	1,319.9733 psf	890.33322 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	41 ft	216.93519 ft	-847.35724 psf	994.04806 psf	670.49389 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	44 ft	221.16217 ft	-1,035.8619 psf	786.76265 psf	530.67811 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	46.190983 ft	224.89091 ft	-1,213.5712 psf	536.90588 psf	362.14759 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	48.816787 ft	230.31614 ft	-1,486.2341 psf	209.84439 psf	182.41494 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

2A.2 Global - Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 318
Date: 01/13/2022
Time: 03:58:28 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/13/2022
Last Solved Time: 04:01:18 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.2 Global - Static (M-P)

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (20.000001, 228.81169) ft
Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf

Direction: Vertical

Coordinates

	X	Y
	43 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft

Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft
Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft
Point 40	1.5 ft	219.4 ft
Point 41	31.5 ft	233.5 ft
Point 42	6.1 ft	233.5 ft
Point 43	14.1 ft	233.5 ft
Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft
Point 54	39 ft	233.5 ft
Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Common Borrow	45,44,46,47	35.36 ft²
Region 8	Common Borrow	36,55,51,35,38,37	75.79 ft²
Region 9		43,53,46,39	58.52 ft²
Region 10		43,42,52,53	12 ft²
Region 11	Common Borrow	47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²
Region 15		47,46,53,52	65.44 ft²
Region 16	Common Borrow	41,39,46,44,33,51,55,54	171.02 ft²
Region 17	Common Borrow	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 1726 of 11466 converged

Current Slip Surface

Slip Surface: 2,555
Factor of Safety: 1.4
Volume: 1,414.2092 ft³
Weight: 173,720.13 lbf
Resisting Moment: 7,600,603.5 lbf·ft
Activating Moment: 5,287,280.8 lbf·ft
Resisting Force: 97,347.4 lbf
Activating Force: 67,744.006 lbf

Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.72383, 192.9891) ft
Entry: (50.251608, 233.58018) ft
Radius: 67.426709 ft
Center: (-12.822974, 257.41205) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-32.411915 ft	192.89439 ft	-578.06471 psf	20.408067 psf	13.765415 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 2	-30.816667 ft	192.44425 ft	-527.22959 psf	104.73335 psf	70.643535 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 3	-28.25 ft	191.78713 ft	-449.62762 psf	232.46507 psf	156.79967 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-25.683333 ft	191.23605 ft	-378.64246 psf	354.76529 psf	239.29221 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-22.75 ft	190.74097 ft	-305.92389 psf	547.95018 psf	369.59707 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-19.7 ft	190.35173 ft	-238.14544 psf	762.16029 psf	514.08361 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-17.05 ft	190.12963 ft	-186.50044 psf	904.20074 psf	609.8911 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-14.55 ft	190.01906 ft	-143.95418 psf	1,015.9524 psf	685.26855 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 9	-12.05 ft	190.00136 ft	-107.20267 psf	1,100.4928 psf	742.29174 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 10	-9.325 ft	190.09234 ft	-74.024233 psf	1,216.6636 psf	820.64998 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-6.375 ft	190.31072 ft	-45.587566 psf	1,352.7804 psf	912.46191 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-4.5 ft	190.50221 ft	-30.801475 psf	1,389.6256 psf	937.31434 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-3.2452353 ft	190.67464 ft	-23.366998 psf	1,333.1144 psf	899.19704 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-1.6452353 ft	190.92259 ft	-15.459087 psf	1,255.3738 psf	846.7603 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
								ESU 2B Medium

Slice 15	0.3 ft	191.28602 ft	-9.7119652 psf	3,945.2118 psf	2,661.079 psf	0 psf	0 psf	Dense Sand/Gravel
Slice 16	2.65 ft	191.79534 ft	-7.1540667 psf	3,795.1301 psf	2,559.8476 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	4.95 ft	192.38082 ft	-10.078507 psf	3,697.8451 psf	2,494.228 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	7.35 ft	193.08713 ft	-19.081688 psf	3,576.4818 psf	2,412.3674 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	9.85 ft	193.92555 ft	-34.867853 psf	3,436.0636 psf	2,317.6542 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	11.4 ft	194.48745 ft	-47.280731 psf	3,345.3873 psf	2,256.4923 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	12.9 ft	195.09829 ft	-66.352671 psf	3,252.1416 psf	2,193.5972 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	14.85 ft	195.93123 ft	-94.504091 psf	3,130.1189 psf	2,111.2919 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	16.3825 ft	196.64489 ft	-120.31334 psf	3,047.6272 psf	2,381.0673 psf	0 psf	0 psf	Gravel Borrow
Slice 24	18.3225 ft	197.62395 ft	-152.2424 psf	2,717.8975 psf	1,833.245 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	20.6375 ft	198.88872 ft	-191.95627 psf	2,574.8219 psf	1,736.7393 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 26	22.9525 ft	200.27527 ft	-239.26898 psf	2,435.8948 psf	1,643.0318 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 27	25.305 ft	201.81961 ft	-287.84498 psf	2,299.3103 psf	1,550.9044 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 28	28 ft	203.78098 ft	-346.66576 psf	2,147.5572 psf	1,448.5456 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 29	29.51 ft	204.93081 ft	-382.79865 psf	2,066.9522 psf	1,394.1769 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 30	30.51 ft	205.76958 ft	-411.42266 psf	1,974.3681 psf	1,331.7281 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 31	31.865 ft	206.92335 ft	-451.28187 psf	1,853.5571 psf	1,250.2401 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 32	33.4475 ft	208.39572 ft	-503.95806 psf	1,711.8631 psf	1,154.6663 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice		210.81767	-594.00316	1,499.3279	1,011.3094			ESU 2B Medium

33	35.8825 ft	ft	psf	psf	psf	0 psf	0 psf	Dense Sand/Gravel
Slice 34	38.05 ft	213.18304 ft	-687.22762 psf	1,310.7504 psf	884.11234 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	41 ft	216.93519 ft	-847.35724 psf	1,037.5984 psf	699.86894 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	44 ft	221.16217 ft	-1,035.8619 psf	891.13166 psf	601.0759 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	46.190983 ft	224.89091 ft	-1,213.5712 psf	654.26939 psf	441.31027 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	48.816787 ft	230.31614 ft	-1,486.2341 psf	269.81641 psf	234.54782 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

2A.3 Global - Pseudo-Static (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 318
Date: 01/13/2022
Time: 03:58:28 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/13/2022
Last Solved Time: 04:01:28 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.3 Global - Pseudo-Static (Spencer)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf

Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (21.860569, 229.72989) ft
Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.196

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf

Direction: Vertical

Coordinates

	X	Y
	43 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft

Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft
Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft
Point 40	1.5 ft	219.4 ft
Point 41	31.5 ft	233.5 ft
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Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft
Point 54	39 ft	233.5 ft

Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Common Borrow (Apparent Cohesion)	45,44,46,47	35.36 ft²
Region 8	Common Borrow (Apparent Cohesion)	36,55,51,35,38,37	75.79 ft²
Region 9		43,53,46,39	58.52 ft²
Region 10		43,42,52,53	12 ft²
Region 11	Common Borrow (Apparent Cohesion)	47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²
Region 15		47,46,53,52	65.44 ft²
Region 16	Common Borrow (Apparent Cohesion)	41,39,46,44,33,51,55,54	171.02 ft²
Region 17	Common Borrow (Apparent Cohesion)	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 1204 of 11466 converged

Current Slip Surface

Slip Surface: 2,029
Factor of Safety: 1.3
Volume: 1,472.3511 ft³
Weight: 180,599.67 lbf
Resisting Moment: 9,582,424.3 lbf·ft

Activating Moment: 7,661,581.3 lbf·ft
Resisting Force: 115,203.84 lbf
Activating Force: 92,086.539 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-34.756941, 192.62766) ft
Entry: (52.676158, 233.61719) ft
Radius: 73.426209 ft
Center: (-14.522295, 263.21071) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-33.42847 ft	192.27359 ft	-553.82155 psf	707.30569 psf	477.08371 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 2	-30.816667 ft	191.6274 ft	-476.25824 psf	879.27764 psf	593.08025 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 3	-28.25 ft	191.091 ft	-406.18922 psf	945.72893 psf	637.90222 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 4	-25.683333 ft	190.64933 ft	-342.03114 psf	976.60911 psf	658.73116 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 5	-22.75 ft	190.26582 ft	-276.27452 psf	1,071.5176 psf	722.74776 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 6	-19.7 ft	189.98073 ft	-214.99513 psf	1,166.1583 psf	786.58371 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 7	-17.05 ft	189.83868 ft	-168.34534 psf	1,190.1523 psf	802.76786 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 8	-14.55 ft	189.79514 ft	-129.98171 psf	1,197.8351 psf	807.94999 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Slice 9	-12.05 ft	189.83679 ft	-96.933383 psf	1,191.6619 psf	803.78611 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 10	-9.325 ft	189.9836 ft	-67.238796 psf	1,228.6053 psf	828.70474 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 11	-6.375 ft	190.253 ft	-41.986049 psf	1,297.4536 psf	875.14353 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 12	-4.5 ft	190.47283 ft	-28.968148 psf	1,303.1065 psf	878.95641 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	-3.2527955 ft	190.65954 ft	-22.535558 psf	1,237.1528 psf	834.4701 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	-1.6527955 ft	190.92517 ft	-15.730192 psf	1,154.1055 psf	778.45399 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	0.3 ft	191.30656 ft	-10.993582 psf	3,608.7289 psf	2,434.1184 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	2.65 ft	191.83059 ft	-9.3532554 psf	3,444.0982 psf	2,323.0736 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	4.95 ft	192.42359 ft	-12.747745 psf	3,349.6031 psf	2,259.3358 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	7.35 ft	193.13007 ft	-21.761226 psf	3,248.2018 psf	2,190.9398 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	9.85 ft	193.96012 ft	-37.025116 psf	3,139.5522 psf	2,117.6547 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Slice 20	11.4 ft	194.51325 ft	-48.890895 psf	3,071.116 psf	2,071.4939 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 21	12.9 ft	195.10966 ft	-67.062023 psf	3,000.5369 psf	2,023.8877 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 22	14.85 ft	195.92024 ft	-93.818311 psf	2,906.8082 psf	1,960.6669 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 23	15.65809 ft	196.27381 ft	-106.00813 psf	2,866.1545 psf	1,933.2456 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 24	16.44059 ft	196.63692 ft	-119.10598 psf	2,838.0823 psf	2,217.3529 psf	0 psf	0 psf	Gravel Borrow
Slice 25	18.90125 ft	197.86186 ft	-157.28615 psf	2,529.8275 psf	1,706.3902 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 26	22.37375 ft	199.7595 ft	-216.88657 psf	2,344.0122 psf	1,581.0562 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 27	25.305 ft	201.54085 ft	-270.45014 psf	2,181.7896 psf	1,471.6357 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 28	28 ft	203.37864 ft	-321.56009 psf	2,024.3266 psf	1,365.4255 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 29	29.51 ft	204.45218 ft	-352.93164 psf	1,936.1394 psf	1,305.9425 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 30	30.51 ft	205.22856 ft	-377.66276 psf	1,842.5701 psf	1,242.8292 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice	31.865 ft	206.29493	-412.0684	1,719.1526	1,159.5831	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

31		ft	psf	psf	psf			(Apparent Cohesion)
Slice 32	33.4475 ft	207.64345 ft	-457.01677 psf	1,573.4456 psf	1,061.3024 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 33	35.8825 ft	209.84442 ft	-533.27235 psf	1,354.1603 psf	913.39265 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 34	38.05 ft	211.96903 ft	-611.47318 psf	1,161.8184 psf	783.65642 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 35	41 ft	215.25948 ft	-742.79274 psf	897.48883 psf	605.36386 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 36	44 ft	218.89587 ft	-894.44424 psf	698.70246 psf	471.28076 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 37	46.352659 ft	222.22556 ft	-1,043.1979 psf	491.90271 psf	331.79256 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 38	49.057978 ft	226.58265 ft	-1,247.2139 psf	260.81775 psf	175.92379 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 39	51.543398 ft	231.27392 ft	-1,477.5989 psf	81.431429 psf	70.787261 psf	100 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

2A.4 Global - Pseudo-Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 318
Date: 01/13/2022
Time: 03:58:28 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/13/2022
Last Solved Time: 04:01:32 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2A.4 Global - Pseudo-Static (M-P)

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (23.356756, 230.46827) ft
Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.196

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf

Direction: Vertical

Coordinates

	X	Y
	43 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft

Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft
Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft
Point 40	1.5 ft	219.4 ft
Point 41	31.5 ft	233.5 ft
Point 42	6.1 ft	233.5 ft
Point 43	14.1 ft	233.5 ft
Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft

Point 54	39 ft	233.5 ft
Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Common Borrow (Apparent Cohesion)	45,44,46,47	35.36 ft²
Region 8	Common Borrow (Apparent Cohesion)	36,55,51,35,38,37	75.79 ft²
Region 9		43,53,46,39	58.52 ft²
Region 10		43,42,52,53	12 ft²
Region 11	Common Borrow (Apparent Cohesion)	47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²
Region 15		47,46,53,52	65.44 ft²
Region 16	Common Borrow (Apparent Cohesion)	41,39,46,44,33,51,55,54	171.02 ft²
Region 17	Common Borrow (Apparent Cohesion)	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 1837 of 11466 converged

Current Slip Surface

Slip Surface: 2,575
Factor of Safety: 1.3
Volume: 1,463.8667 ft³
Weight: 179,655.51 lbf

Resisting Moment: 9,369,898.3 lbf·ft
Activating Moment: 7,486,242.8 lbf·ft
Resisting Force: 114,533.43 lbf
Activating Force: 91,449.07 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.72383, 192.9891) ft
Entry: (53.143274, 233.62432) ft
Radius: 72.452532 ft
Center: (-13.193045, 262.75956) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-32.411915 ft	192.90328 ft	-578.61944 psf	76.106242 psf	51.334308 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 2	-30.816667 ft	192.49558 ft	-530.4326 psf	178.95001 psf	120.70331 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 3	-28.25 ft	191.901 ft	-456.73283 psf	344.47359 psf	232.35037 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 4	-25.683333 ft	191.40366 ft	-389.10136 psf	515.29602 psf	347.57156 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 5	-22.75 ft	190.9594 ft	-319.55363 psf	778.31133 psf	524.97762 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 6	-19.7 ft	190.61351 ft	-254.48061 psf	1,072.9331 psf	723.70254 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 7	-17.05 ft	190.42059 ft	-204.65682 psf	1,280.3088 psf	863.57921 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 8	-14.55 ft	190.33053 ft	-163.38964 psf	1,441.4971 psf	972.3021 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent

								Cohesion)
Slice 9	-12.05 ft	190.32684 ft	-127.51216 psf	1,556.4548 psf	1,049.842 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 10	-9.325 ft	190.42544 ft	-94.809576 psf	1,680.8729 psf	1,133.7631 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 11	-6.375 ft	190.64376 ft	-66.369596 psf	1,793.3564 psf	1,209.6342 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 12	-4.5 ft	190.83156 ft	-51.352647 psf	1,798.669 psf	1,213.2176 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	-2.6006305 ft	191.10153 ft	-40.585987 psf	1,664.8875 psf	1,122.9808 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	-1.0006305 ft	191.34035 ft	-32.107758 psf	1,547.2417 psf	1,043.6277 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	0.3 ft	191.58502 ft	-28.369589 psf	4,146.2205 psf	2,796.661 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	2.65 ft	192.07025 ft	-24.308367 psf	3,885.4234 psf	2,620.7512 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	4.95 ft	192.62549 ft	-25.345922 psf	3,679.1315 psf	2,481.6056 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	7.35 ft	193.29264 ft	-31.905682 psf	3,452.6177 psf	2,328.82 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	9.85 ft	194.0817 ft	-44.61136 psf	3,217.2005 psf	2,170.0291 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent

								Cohesion)
Slice 20	11.4 ft	194.60936 ft	-54.887981 psf	3,076.1891 psf	2,074.9157 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 21	12.9 ft	195.18096 ft	-71.510939 psf	2,941.9737 psf	1,984.3863 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 22	14.85 ft	195.95915 ft	-96.24606 psf	2,776.5637 psf	1,872.8159 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 23	16.3825 ft	196.62393 ft	-119.00538 psf	2,675.3048 psf	2,090.1772 psf	0 psf	0 psf	Gravel Borrow
Slice 24	18.90125 ft	197.83211 ft	-155.42947 psf	2,301.0995 psf	1,552.1112 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 25	22.37375 ft	199.66915 ft	-211.24909 psf	2,079.5704 psf	1,402.6879 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 26	25.305 ft	201.39769 ft	-261.51667 psf	1,921.074 psf	1,295.7808 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 27	28 ft	203.1846 ft	-309.45164 psf	1,793.9106 psf	1,210.008 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 28	29.51 ft	204.22906 ft	-339.0095 psf	1,730.6803 psf	1,167.3586 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 29	30.51 ft	204.98524 ft	-362.47954 psf	1,657.5688 psf	1,118.0443 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 30	31.865 ft	206.02399 ft	-395.16179 psf	1,563.5425 psf	1,054.6227 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 2B Medium Dense

Slice 31	33.4475 ft	207.33848 ft	-437.98633 psf	1,455.9412 psf	982.04475 psf	200 psf	0 psf	Sand/Gravel (Apparent Cohesion)
Slice 32	35.8825 ft	209.48461 ft	-510.82019 psf	1,297.8562 psf	875.41503 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 33	38.05 ft	211.55689 ft	-585.75588 psf	1,159.9169 psf	782.37383 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 34	41 ft	214.76599 ft	-711.99882 psf	962.14614 psf	648.97576 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 35	44 ft	218.31106 ft	-857.9524 psf	823.45292 psf	555.42601 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 36	46.525357 ft	221.82298 ft	-1,013.7444 psf	618.46375 psf	417.15906 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 37	49.576072 ft	226.70365 ft	-1,241.7667 psf	328.57709 psf	221.62805 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 38	52.122352 ft	231.49172 ft	-1,476.6657 psf	92.340339 psf	80.270232 psf	100 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

2B.1 Global - Static FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Bo Zhang
Revision Number: 314
Date: 01/12/2022
Time: 10:44:22 AM
Tool Version: 11.1.1.22700
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/12/2022
Last Solved Time: 10:49:10 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.1 Global - Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb

Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (20.000001, 233.5) ft

Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft
Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft
Point 40	1.5 ft	219.4 ft
Point 41	31.5 ft	233.5 ft
Point 42	6.1 ft	233.5 ft
Point 43	14.1 ft	233.5 ft

Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft
Point 54	39 ft	233.5 ft
Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Forward Compatible Wall	45,44,46,47	35.36 ft²
Region 8	Common Borrow	36,55,51,35,38,37	75.79 ft²
Region 9	Lightweight EPS	43,53,46,39	58.52 ft²
Region 10	Forward Compatible Wall	43,42,52,53	12 ft²
Region 11		47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²
Region 15	Forward Compatible Wall	47,46,53,52	65.44 ft²
Region 16	Lightweight EPS	41,39,46,44,33,51,55,54	171.02 ft²
Region 17	Common Borrow	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 1520 of 11466 converged

Current Slip Surface

Slip Surface: 3,101
Factor of Safety: 1.5
Volume: 1,536.2538 ft³
Weight: 163,163.5 lbf
Resisting Moment: 7,456,039.3 lbf·ft
Activating Moment: 4,992,124.5 lbf·ft
Resisting Force: 97,655.951 lbf
Activating Force: 65,394.513 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-30.671631, 193.19275) ft
Entry: (50.601608, 233.58552) ft
Radius: 66.587809 ft
Center: (-11.723356, 257.02769) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-29.103723 ft	192.76867 ft	-523.04891 psf	118.23679 psf	79.751725 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 2	-25.967908 ft	192.00113 ft	-430.4414 psf	307.12896 psf	207.1611 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 3	-22.75 ft	191.38052 ft	-345.83178 psf	522.59411 psf	352.49418 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-19.7 ft	190.93441 ft	-274.50507 psf	714.07291 psf	481.64826 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-17.05 ft	190.66512 ft	-219.91518 psf	815.53796 psf	550.0873 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-14.55 ft	190.51167 ft	-174.69272 psf	888.52104 psf	599.31501 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-12.05 ft	190.45241 ft	-135.3483 psf	940.66203 psf	634.48455 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-9.325 ft	190.49946 ft	-99.428369 psf	1,034.8536 psf	698.01759 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 9	-6.375 ft	190.67152 ft	-68.10139 psf	1,161.3319 psf	783.32829 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 10	-4.5 ft	190.83405 ft	-51.508337 psf	1,199.8332 psf	809.29773 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-2.6625312 ft	191.07519 ft	-39.846403 psf	1,125.638 psf	759.25244 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-1.0625312 ft	191.29903 ft	-30.434203 psf	1,062.6248 psf	716.74947 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	0.3 ft	191.54573 ft	-25.917929 psf	3,749.3773 psf	2,528.987 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	2.65 ft	192.02034 ft	-21.193533 psf	3,556.5692 psf	2,398.9362 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	4.95 ft	192.57209 ft	-22.013664 psf	3,368.4004 psf	2,272.0147 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	7.1 ft	193.16431 ft	-27.551338 psf	4,933.148 psf	3,327.4504 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	9.6 ft	193.96626 ft	-41.061281 psf	4,889.6345 psf	3,298.1001 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	11.4 ft	194.58456 ft	-53.340267 psf	4,692.394 psf	3,165.0597 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	12.9 ft	195.17336 ft	-71.036518 psf	4,525.1291 psf	3,052.2382 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	14.85 ft	195.97751 ft	-97.391985 psf	2,828.1284 psf	1,907.5967 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	16.3825 ft	196.66833 ft	-121.77589 psf	2,697.3789 psf	2,107.4234 psf	0 psf	0 psf	Gravel Borrow
Slice 22	18.3225 ft	197.61809 ft	-151.8768 psf	2,394.0129 psf	1,614.7821 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	20.6375 ft	198.8473 ft	-189.3718 psf	2,295.7307 psf	1,548.4899 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	22.9525 ft	200.19739 ft	-234.40916 psf	2,188.8188 psf	1,476.377 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	25.305 ft	201.70347 ft	-280.59734 psf	2,071.1978 psf	1,397.0405 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 26	28 ft	203.61892 ft	-336.5534 psf	1,922.2807 psf	1,296.5947 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 27	29.51 ft	204.74245 ft	-371.0445 psf	1,840.3438 psf	1,241.3276 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
								ESU 2B Medium

Slice 28	30.51 ft	205.56275 ft	-398.51615 psf	1,779.8865 psf	1,200.5486 psf	0 psf	0 psf	Dense Sand/Gravel
Slice 29	31.865 ft	206.69124 ft	-436.79766 psf	1,698.4587 psf	1,145.6248 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 30	33.4475 ft	208.13206 ft	-487.50578 psf	1,595.6423 psf	1,076.2743 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 31	35.8825 ft	210.50259 ft	-574.34203 psf	1,431.9559 psf	965.86645 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 32	38.05 ft	212.81793 ft	-664.44438 psf	1,277.7929 psf	861.88222 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	40.5 ft	215.78694 ft	-788.24917 psf	1,217.6007 psf	821.28203 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	43.5 ft	219.9186 ft	-970.80587 psf	880.17528 psf	593.68572 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	46.447672 ft	224.76067 ft	-1,199.0047 psf	545.65025 psf	368.04574 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	49.248476 ft	230.47803 ft	-1,485.5061 psf	203.24754 psf	176.68039 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

2B.2 Global - Static FC Wall (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Bo Zhang
Revision Number: 314
Date: 01/12/2022
Time: 10:44:22 AM
Tool Version: 11.1.1.22700
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/12/2022
Last Solved Time: 10:49:14 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.2 Global - Static FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced

Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20

Right Type: Range
Right-Zone Left Coordinate: (20.000001, 233.5) ft
Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft
Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft
Point 40	1.5 ft	219.4 ft

Point 41	31.5 ft	233.5 ft
Point 42	6.1 ft	233.5 ft
Point 43	14.1 ft	233.5 ft
Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft
Point 54	39 ft	233.5 ft
Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Forward Compatible Wall	45,44,46,47	35.36 ft²
Region 8	Common Borrow	36,55,51,35,38,37	75.79 ft²
Region 9	Lightweight EPS	43,53,46,39	58.52 ft²
Region 10	Forward Compatible Wall	43,42,52,53	12 ft²
Region 11		47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²
Region 15	Forward Compatible Wall	47,46,53,52	65.44 ft²
Region 16	Lightweight EPS	41,39,46,44,33,51,55,54	171.02 ft²
Region			

17	Common Borrow	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 1764 of 11466 converged

Current Slip Surface

Slip Surface: 3,101
Factor of Safety: 1.5
Volume: 1,536.2538 ft³
Weight: 163,163.5 lbf
Resisting Moment: 7,470,604.9 lbf·ft
Activating Moment: 4,992,124.5 lbf·ft
Resisting Force: 97,699.546 lbf
Activating Force: 65,300.757 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-30.671631, 193.19275) ft
Entry: (50.601608, 233.58552) ft
Radius: 66.587809 ft
Center: (-11.723356, 257.02769) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-29.103723 ft	192.76867 ft	-523.04891 psf	73.610151 psf	49.650674 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 2	-25.967908 ft	192.00113 ft	-430.4414 psf	221.13724 psf	149.15895 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 3	-22.75 ft	191.38052 ft	-345.83178 psf	428.02183 psf	288.70437 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-19.7 ft	190.93441 ft	-274.50507 psf	647.4718 psf	436.72525 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-17.05 ft	190.66512 ft	-219.91518 psf	799.05469 psf	538.96919 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-14.55 ft	190.51167 ft	-174.69272 psf	922.90431 psf	622.50682 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-12.05 ft	190.45241 ft	-135.3483 psf	1,021.5192 psf	689.02342 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-9.325 ft	190.49946 ft	-99.428369 psf	1,154.2945 psf	778.58149 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 9	-6.375 ft	190.67152 ft	-68.10139 psf	1,308.9014 psf	882.86512 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 10	-4.5 ft	190.83405 ft	-51.508337 psf	1,356.7884 psf	915.16531 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-2.6625312 ft	191.07519 ft	-39.846403 psf	1,279.5664 psf	863.07843 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-1.0625312 ft	191.29903 ft	-30.434203 psf	1,208.6673 psf	815.25641 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	0.3 ft	191.54573 ft	-25.917929 psf	3,966.9348 psf	2,675.7313 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	2.65 ft	192.02034 ft	-21.193533 psf	3,754.6028 psf	2,532.5116 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	4.95 ft	192.57209 ft	-22.013664 psf	3,526.871 psf	2,378.9045 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	7.1 ft	193.16431 ft	-27.551338 psf	5,080.1017 psf	3,426.5718 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	9.6 ft	193.96626 ft	-41.061281 psf	4,966.5129 psf	3,349.9553 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	11.4 ft	194.58456 ft	-53.340267 psf	4,714.7482 psf	3,180.1378 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	12.9 ft	195.17336 ft	-71.036518 psf	4,503.2813 psf	3,037.5016 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	14.85 ft	195.97751 ft	-97.391985 psf	2,751.5284 psf	1,855.9293 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	16.3825 ft	196.66833 ft	-121.77589 psf	2,607.2458 psf	2,037.0037 psf	0 psf	0 psf	Gravel Borrow
Slice 22	18.3225 ft	197.61809 ft	-151.8768 psf	2,252.8747 psf	1,519.5832 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	20.6375 ft	198.8473 ft	-189.3718 psf	2,125.2683 psf	1,433.5116 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	22.9525 ft	200.19739 ft	-234.40916 psf	2,000.483 psf	1,349.3428 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	25.305 ft	201.70347 ft	-280.59734 psf	1,876.9752 psf	1,266.0358 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 26	28 ft	203.61892 ft	-336.5534 psf	1,736.7233 psf	1,171.4347 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
								ESU 2B Medium

Slice 27	29.51 ft	204.74245 ft	-371.0445 psf	1,665.3716 psf	1,123.3073 psf	0 psf	0 psf	Dense Sand/Gravel
Slice 28	30.51 ft	205.56275 ft	-398.51615 psf	1,615.4648 psf	1,089.6448 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 29	31.865 ft	206.69124 ft	-436.79766 psf	1,550.5301 psf	1,045.8457 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 30	33.4475 ft	208.13206 ft	-487.50578 psf	1,472.0255 psf	992.89372 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 31	35.8825 ft	210.50259 ft	-574.34203 psf	1,352.3638 psf	912.18087 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 32	38.05 ft	212.81793 ft	-664.44438 psf	1,242.8916 psf	838.34099 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	40.5 ft	215.78694 ft	-788.24917 psf	1,254.7536 psf	846.34201 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	43.5 ft	219.9186 ft	-970.80587 psf	974.57752 psf	657.36084 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	46.447672 ft	224.76067 ft	-1,199.0047 psf	666.17182 psf	449.33857 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	49.248476 ft	230.47803 ft	-1,485.5061 psf	265.84408 psf	231.09474 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

2B.3 Global - Pseudo-Static FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Bo Zhang
Revision Number: 314
Date: 01/12/2022
Time: 10:44:22 AM
Tool Version: 11.1.1.22700
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/12/2022
Last Solved Time: 10:49:24 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.3 Global - Pseudo-Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb

Unit Weight: 130 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (20.000001, 233.5) ft

Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.197

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft
Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft

Point 40	1.5 ft	219.4 ft
Point 41	31.5 ft	233.5 ft
Point 42	6.1 ft	233.5 ft
Point 43	14.1 ft	233.5 ft
Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft
Point 54	39 ft	233.5 ft
Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Forward Compatible Wall	45,44,46,47	35.36 ft²
Region 8	Common Borrow (Apparent Cohesion)	36,55,51,35,38,37	75.79 ft²
Region 9	Lightweight EPS	43,53,46,39	58.52 ft²
Region 10	Forward Compatible Wall	43,42,52,53	12 ft²
Region 11		47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²
Region 15	Forward Compatible Wall	47,46,53,52	65.44 ft²
Region 16	Lightweight EPS	41,39,46,44,33,51,55,54	171.02 ft²

Region 17	Common Borrow (Apparent Cohesion)	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 971 of 11466 converged

Current Slip Surface

Slip Surface: 2,070
Factor of Safety: 1.3
Volume: 1,662.3467 ft³
Weight: 177,985.54 lbf
Resisting Moment: 10,585,397 lbf·ft
Activating Moment: 8,057,639 lbf·ft
Resisting Force: 118,889.15 lbf
Activating Force: 90,479.516 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-34.756941, 192.62766) ft
Entry: (56.001378, 233.66796) ft
Radius: 79.563783 ft
Center: (-14.943487, 269.68492) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-33.42847 ft	192.31028 ft	-556.11098 psf	653.50667 psf	440.79581 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 2	-30.816667 ft	191.73159 ft	-482.75933 psf	812.05672 psf	547.73917 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 3	-28.25 ft	191.25255 ft	-416.26943 psf	875.6494 psf	590.63298 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 4	-25.683333 ft	190.85997 ft	-355.17489 psf	907.42491 psf	612.06583 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 5	-22.75 ft	190.5224 ft	-292.28489 psf	1,004.071 psf	677.25443 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent

								Cohesion)
Slice 6	-19.7 ft	190.27583 ft	-233.40945 psf	1,102.4351 psf	743.60186 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 7	-16.425 ft	190.15704 ft	-179.29946 psf	1,134.0562 psf	764.93059 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 8	-12.675 ft	190.17561 ft	-126.98744 psf	1,143.319 psf	771.17839 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 9	-9.325 ft	190.33354 ft	-89.075424 psf	1,187.3695 psf	800.89085 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 10	-6.375 ft	190.59779 ft	-63.500632 psf	1,263.8719 psf	852.49236 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 11	-4.5 ft	190.81055 ft	-50.042038 psf	1,274.4901 psf	859.65442 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 12	-2.5 ft	191.11692 ft	-40.07564 psf	1,173.1915 psf	791.32769 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	0.3 ft	191.6046 ft	-29.591407 psf	3,611.997 psf	2,436.3227 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	2.65 ft	192.09965 ft	-26.142884 psf	3,390.8409 psf	2,287.151 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	4.95 ft	192.65743 ft	-27.339381 psf	3,182.294 psf	2,146.4844 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	7.1 ft	193.24281 ft	-32.449431 psf	4,589.33 psf	3,095.5422 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent

								Cohesion)
Slice 17	9.6 ft	194.01772 ft	-44.272157 psf	4,426.025 psf	2,985.3915 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	11.4 ft	194.60953 ft	-54.898289 psf	4,225.5963 psf	2,850.2007 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	12.9 ft	195.16315 ft	-70.399693 psf	4,059.6177 psf	2,738.2467 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 20	14.85 ft	195.9144 ft	-93.454108 psf	2,517.8407 psf	1,698.305 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 21	15.699077 ft	196.25865 ft	-104.56166 psf	2,448.6749 psf	1,651.6521 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 22	16.481577 ft	196.59383 ft	-115.91684 psf	2,393.5692 psf	1,870.0612 psf	0 psf	0 psf	Gravel Borrow
Slice 23	18.90125 ft	197.70404 ft	-147.43779 psf	2,094.8932 psf	1,413.0233 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 24	22.37375 ft	199.44281 ft	-197.1256 psf	1,956.6589 psf	1,319.7831 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 25	25.305 ft	201.06615 ft	-240.82905 psf	1,834.2519 psf	1,237.2185 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 26	28 ft	202.72914 ft	-281.03125 psf	1,712.3055 psf	1,154.9646 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 27	29.51 ft	203.69793 ft	-305.86691 psf	1,646.6629 psf	1,110.6881 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 2B Medium Dense

Slice 28	30.51 ft	204.39388 ft	-325.5784 psf	1,599.5285 psf	1,078.8956 psf	200 psf	0 psf	Sand/Gravel (Apparent Cohesion)
Slice 29	31.865 ft	205.34864 ft	-353.01972 psf	1,536.4731 psf	1,036.3642 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 30	33.4475 ft	206.54734 ft	-388.61925 psf	1,458.8915 psf	984.03474 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 31	35.8825 ft	208.49171 ft	-448.86284 psf	1,337.8477 psf	902.38964 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 32	38.05 ft	210.35143 ft	-510.53497 psf	1,226.6021 psf	827.35353 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 33	40.5 ft	212.65828 ft	-593.02074 psf	1,212.3738 psf	817.75646 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 34	43.5 ft	215.74178 ft	-710.17214 psf	962.79607 psf	649.41415 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 35	46.669017 ft	219.41241 ft	-859.7211 psf	701.03826 psf	472.85628 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 36	50.007051 ft	223.82153 ft	-1,051.111 psf	431.563 psf	291.09292 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 37	53.345085 ft	228.98556 ft	-1,289.6072 psf	173.65588 psf	117.13237 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 38	55.50774 ft	232.72696 ft	-1,468.8179 psf	44.028516 psf	38.273405 psf	100 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

2B.4 Global - Pseudo-Static FC Wall (M-P)

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File Information

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Last Edited By: Bo Zhang
Revision Number: 314
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File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/12/2022
Last Solved Time: 10:49:28 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

2B.4 Global - Pseudo-Static FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced

Geometry Settings
- Minimum Slip Surface Depth: 0.1 ft
- Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

SEW Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
- Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40.9, 191.85458) ft
Left-Zone Right Coordinate: (-0.9, 199.92697) ft
Left-Zone Increment: 20

Right Type: Range
Right-Zone Left Coordinate: (20.000001, 233.5) ft
Right-Zone Right Coordinate: (65, 233.85753) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.197

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft

	80 ft	235.2 ft

Geometry

Name: 2. Global Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	17.1 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	214.2 ft
Point 36	45 ft	233.5 ft

Point 37	37.1 ft	228.2 ft
Point 38	29.4 ft	222.3 ft
Point 39	29.5 ft	233.5 ft
Point 40	1.5 ft	219.4 ft
Point 41	31.5 ft	233.5 ft
Point 42	6.1 ft	233.5 ft
Point 43	14.1 ft	233.5 ft
Point 44	14.1 ft	219.4 ft
Point 45	6.1 ft	219.4 ft
Point 46	14.1 ft	225.9 ft
Point 47	6.1 ft	221.74 ft
Point 48	15.6 ft	214.2 ft
Point 49	15.6 ft	196.3 ft
Point 50	17.1 ft	208.4 ft
Point 51	17.1 ft	219.4 ft
Point 52	6.1 ft	232 ft
Point 53	14.1 ft	232 ft
Point 54	39 ft	233.5 ft
Point 55	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	SEW Wall	27,30,31,28,34,49,48,33,44,45,40	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,50,32,49,34,25,9,8,26	856.44 ft²
Region 7	Forward Compatible Wall	45,44,46,47	35.36 ft²
Region 8	Common Borrow (Apparent Cohesion)	36,55,51,35,38,37	75.79 ft²
Region 9	Lightweight EPS	43,53,46,39	58.52 ft²
Region 10	Forward Compatible Wall	43,42,52,53	12 ft²
Region 11		47,40,45	5.382 ft²
Region 12	Gravel Borrow	32,50,35,48,49	26.85 ft²
Region 13	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	35,50,13,12,36,37,38	241.79 ft²
Region 14	Gravel Borrow	33,48,35,51	7.8 ft²

Region 15	Forward Compatible Wall	47,46,53,52	65.44 ft²
Region 16	Lightweight EPS	41,39,46,44,33,51,55,54	171.02 ft²
Region 17	Common Borrow (Apparent Cohesion)	36,54,55	9 ft²

Slip Results

Slip Surfaces Analysed: 1712 of 11466 converged

Current Slip Surface

Slip Surface: 2,070
Factor of Safety: 1.3
Volume: 1,662.3467 ft³
Weight: 177,985.54 lbf
Resisting Moment: 10,563,522 lbf·ft
Activating Moment: 8,057,639 lbf·ft
Resisting Force: 118,787.18 lbf
Activating Force: 90,612.569 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-34.756941, 192.62766) ft
Entry: (56.001378, 233.66796) ft
Radius: 79.563783 ft
Center: (-14.943487, 269.68492) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-33.42847 ft	192.31028 ft	-556.11098 psf	139.17015 psf	93.87145 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 2	-30.816667 ft	191.73159 ft	-482.75933 psf	313.14298 psf	211.21761 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 3	-28.25 ft	191.25255 ft	-416.26943 psf	469.82018 psf	316.89771 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 4	-25.683333 ft	190.85997 ft	-355.17489 psf	626.85026 psf	422.81584 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Slice 5	-22.75 ft	190.5224 ft	-292.28489 psf	865.96343 psf	584.09971 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 6	-19.7 ft	190.27583 ft	-233.40945 psf	1,127.3446 psf	760.40357 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 7	-16.425 ft	190.15704 ft	-179.29946 psf	1,336.6428 psf	901.57694 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 8	-12.675 ft	190.17561 ft	-126.98744 psf	1,502.1328 psf	1,013.2013 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 9	-9.325 ft	190.33354 ft	-89.075424 psf	1,625.5939 psf	1,096.4769 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 10	-6.375 ft	190.59779 ft	-63.500632 psf	1,723.3027 psf	1,162.3824 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 11	-4.5 ft	190.81055 ft	-50.042038 psf	1,725.9471 psf	1,164.166 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 12	-2.5 ft	191.11692 ft	-40.07564 psf	1,591.1732 psf	1,073.2598 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	0.3 ft	191.6046 ft	-29.591407 psf	4,026.9843 psf	2,716.2352 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	2.65 ft	192.09965 ft	-26.142884 psf	3,723.229 psf	2,511.3497 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	4.95 ft	192.65743 ft	-27.339381 psf	3,418.5136 psf	2,305.8166 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Slice 16	7.1 ft	193.24281 ft	-32.449431 psf	4,731.9096 psf	3,191.7133 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	9.6 ft	194.01772 ft	-44.272157 psf	4,453.2181 psf	3,003.7336 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	11.4 ft	194.60953 ft	-54.898289 psf	4,173.8127 psf	2,815.2722 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	12.9 ft	195.16315 ft	-70.399693 psf	3,950.0378 psf	2,664.3342 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 20	14.85 ft	195.9144 ft	-93.454108 psf	2,381.4239 psf	1,606.2907 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 21	15.699077 ft	196.25865 ft	-104.56166 psf	2,290.4128 psf	1,544.9029 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 22	16.481577 ft	196.59383 ft	-115.91684 psf	2,217.9982 psf	1,732.8901 psf	0 psf	0 psf	Gravel Borrow
Slice 23	18.90125 ft	197.70404 ft	-147.43779 psf	1,877.3546 psf	1,266.2917 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 24	22.37375 ft	199.44281 ft	-197.1256 psf	1,698.7609 psf	1,145.8287 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 25	25.305 ft	201.06615 ft	-240.82905 psf	1,567.1358 psf	1,057.0464 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 26	28 ft	202.72914 ft	-281.03125 psf	1,456.6708 psf	982.53686 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice	29.51 ft	203.69793	-305.86691	1,403.5072	946.67758	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

27		ft	psf	psf	psf			(Apparent Cohesion)
Slice 28	30.51 ft	204.39388 ft	-325.5784 psf	1,368.2791 psf	922.91594 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 29	31.865 ft	205.34864 ft	-353.01972 psf	1,323.5386 psf	892.73809 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 30	33.4475 ft	206.54734 ft	-388.61925 psf	1,272.2798 psf	858.16355 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 31	35.8825 ft	208.49171 ft	-448.86284 psf	1,198.1308 psf	808.14944 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 32	38.05 ft	210.35143 ft	-510.53497 psf	1,134.1127 psf	764.96864 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 33	40.5 ft	212.65828 ft	-593.02074 psf	1,196.3858 psf	806.9724 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 34	43.5 ft	215.74178 ft	-710.17214 psf	1,013.506 psf	683.61842 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 35	46.669017 ft	219.41241 ft	-859.7211 psf	800.35723 psf	539.84777 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 36	50.007051 ft	223.82153 ft	-1,051.111 psf	540.14287 psf	364.33097 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 37	53.345085 ft	228.98556 ft	-1,289.6072 psf	222.12328 psf	149.82404 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 1B Medium Dense to Very

Slice 38	55.50774 ft	232.72696 ft	-1,468.8179 psf	44.552314 psf	38.728735 psf	100 psf	0 psf	Dense Coarse-Grained Fill (Apparent Cohesion)

1A. Static (Spencer)

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File Information

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Last Solved Time: 05:51:25 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A. Static (Spencer)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 4 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3

Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 15 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb

Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A Loose to Med Dense Granular Fill (Original)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Quarry Spalls

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-86, 193.85013) ft
Left-Zone Right Coordinate: (-26, 221.6978) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (-19.452, 224.97337) ft
Right-Zone Right Coordinate: (60, 227.4) ft
Right-Zone Increment: 38
Radius Increments: 25

Slip Surface Limits

Left Coordinate: (-120, 183.7) ft
Right Coordinate: (60, 227.4) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-120 ft	171.9 ft
Coordinate 2	-103.2 ft	175.5 ft
Coordinate 3	-94.5 ft	177 ft

Coordinate 4	-92 ft	177.8 ft
Coordinate 5	-90.25762 ft	179.711 ft
Coordinate 6	-81.894 ft	180.175 ft
Coordinate 7	-65.834 ft	181.109 ft
Coordinate 8	-58.616 ft	181.817 ft
Coordinate 9	-44.983 ft	184.066 ft
Coordinate 10	-32.584 ft	185.508 ft
Coordinate 11	-27.777 ft	186.156 ft
Coordinate 12	-25.31 ft	186.665 ft
Coordinate 13	-21.273 ft	187.982 ft
Coordinate 14	-18.881 ft	189.313 ft
Coordinate 15	-13.948 ft	192.408 ft
Coordinate 16	-9.34 ft	198.085 ft
Coordinate 17	-7.036 ft	200.627 ft
Coordinate 18	-2.894 ft	203.633 ft
Coordinate 19	8.368 ft	210.024 ft
Coordinate 20	18.083 ft	214.581 ft
Coordinate 21	22.799 ft	216.342 ft
Coordinate 22	25.82 ft	217.166 ft
Coordinate 23	29.666 ft	217.984 ft
Coordinate 24	37.76 ft	218.338 ft
Coordinate 25	60 ft	219.309 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-3.5 ft	227.3 ft
	0.2 ft	227.6 ft
	37.7 ft	228.2 ft
	60 ft	228.4 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	60 ft	170 ft
Point 2	-4.3 ft	196.6 ft

Point 3	4 ft	225.3 ft
Point 4	-120 ft	170 ft
Point 5	0.2 ft	226.6 ft
Point 6	37.7 ft	227.2 ft
Point 7	-92.7 ft	193.2 ft
Point 8	-55.6 ft	196.8 ft
Point 9	-50 ft	199.6 ft
Point 10	-4.3 ft	225.7 ft
Point 11	-11.9 ft	219.8 ft
Point 12	-22.9 ft	213 ft
Point 13	-41.2 ft	203.1 ft
Point 14	-53.8 ft	193.9 ft
Point 15	-24.6 ft	205.1 ft
Point 16	-67.8 ft	191.1 ft
Point 17	-92 ft	177.8 ft
Point 18	-85 ft	187.7 ft
Point 19	-88.9 ft	181.2 ft
Point 20	-100.8 ft	190.8 ft
Point 21	-80.509 ft	194.38295 ft
Point 22	-16.8 ft	226.3 ft
Point 23	-35.1 ft	217.1 ft
Point 24	-35.1 ft	226.3 ft
Point 25	-53.2 ft	198.1 ft
Point 26	-78.51 ft	189.1 ft
Point 27	-7.6 ft	173.4 ft
Point 28	60 ft	185.2 ft
Point 29	60 ft	211.2 ft
Point 30	60 ft	225.3 ft
Point 31	-24.6 ft	195.3 ft
Point 32	-44.8 ft	190.9 ft
Point 33	-55.8 ft	188.8 ft
Point 34	-64.2 ft	187.5 ft
Point 35	-87.6 ft	183.3 ft
Point 36	-94.5 ft	177 ft
Point 37	-120 ft	171.9 ft
Point 38	60 ft	227.4 ft
Point 39	-69.1 ft	186.6 ft
Point 40	3.8 ft	225.4 ft
Point 41	-24.9 ft	196.1 ft
Point 42	-26.3 ft	195.8 ft
Point 43	-41.6 ft	192.6 ft
Point 44	-57 ft	189.2 ft
Point 45	-120 ft	183.7 ft
Point 46	0.9 ft	226.5 ft
Point 47	-11.6 ft	216.6 ft
Point 48	-19.6 ft	210.5 ft
Point 49	-24.7 ft	206.4 ft
Point 50	-28.6 ft	204.5 ft
Point 51	-41.7 ft	199.9 ft

Point 52	-53.6 ft	195.7 ft
Point 53	-46.7 ft	201 ft
Point 54	-111.255 ft	184.5 ft
Point 55	-103.2 ft	175.5 ft
Point 56	-105.5313 ft	188.8 ft
Point 57	-27.1 ft	226.3 ft
Point 58	-35.1 ft	215.1 ft
Point 59	-27.1 ft	221.14754 ft
Point 60	-39.1 ft	215.1 ft
Point 61	-120 ft	178.102 ft
Point 62	-107.308 ft	180.256 ft
Point 63	-35.1 ft	213.1 ft
Point 64	-27.1 ft	213.1 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	27,28,29,2	1,600.6 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,28,27,2,29,30,3,31,32,33,34,39,35,19,17,36,55,37,4	4,026.8 ft²
Region 3	Gravel Borrow	5,46,40,3,30,38,6	101.83 ft²
Region 4	ESU 2B Medium Dense Sand/Gravel	39,34,33,32,31,3,40,41,42,43,44	52.08 ft²
Region 5	Quarry Spalls	36,17,19,35,18,54,62,55	182.94 ft²
Region 6	Gravel Borrow	20,7,21,8,25,52,14,16,26,18,54,56	272.45 ft²
Region 7	ESU 1A Loose to Med Dense Granular Fill (Original)	5,46,47,48,49,50,51,52,25,9,53,13,12,11,10	199.45 ft²
Region 8	Common Borrow	5,22,59,64,63,58,60,21,8,25,9,53,13,12,11,10	544.6 ft²
Region 9	ESU 2A Very Loose to Loose Sand/Gravel	40,41,42,43,44,39,35,18,26,16,14,52,51,50,49,48,47,46	545.83 ft²
Region 10	Common Borrow	58,63,64,59,23	48.19 ft²
Region 11		22,57,59	26.535 ft²
Region 12	ESU 2A Very Loose to Loose Sand/Gravel	45,61,62,54	55.661 ft²
Region 13	ESU 4B Dense to Very Dense Sand/Gravel	61,37,55,62	86.703 ft²
Region 14		24,23,59,57	57.41 ft²
Region 15	Common Borrow	23,60,58	4 ft²

Slip Results

Slip Surfaces Analysed: 29900 of 31434 converged

Current Slip Surface

Slip Surface: 2,084
Factor of Safety: 1.28
Volume: 182.3259 ft³
Weight: 21,879.108 lbf
Resisting Moment: 2,308,143.7 lbf·ft
Activating Moment: 1,809,627.1 lbf·ft
Resisting Force: 11,025.512 lbf
Activating Force: 8,644.0212 lbf
Slip Rank: 1 of 31,434 slip surfaces
Exit: (-79.732674, 194.77135) ft
Entry: (-15.566887, 226.32176) ft
Radius: 187.2457 ft
Center: (-128.75123, 375.48697) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-78.574451 ft	195.09351 ft	-918.86842 psf	29.983556 psf	18.735805 psf	0 psf	0 psf	Common Borrow
Slice 2	-76.258006 ft	195.75395 ft	-951.67319 psf	86.910048 psf	54.307425 psf	0 psf	0 psf	Common Borrow
Slice 3	-73.94156 ft	196.44679 ft	-986.50008 psf	138.65353 psf	86.640344 psf	0 psf	0 psf	Common Borrow
Slice 4	-71.625114 ft	197.17241 ft	-1,023.3726 psf	185.34899 psf	115.81891 psf	0 psf	0 psf	Common Borrow
Slice 5	-69.308669 ft	197.93122 ft	-1,062.316 psf	227.12468 psf	141.92325 psf	0 psf	0 psf	Common Borrow
Slice 6	-66.992223 ft	198.72364 ft	-1,103.3567 psf	264.10251 psf	165.02956 psf	0 psf	0 psf	Common Borrow
Slice 7	-64.631 ft	199.56678 ft	-1,144.4026 psf	296.94061 psf	185.54909 psf	0 psf	0 psf	Common Borrow
Slice 8	-62.225 ft	200.46252 ft	-1,185.5698 psf	325.55604 psf	203.42999 psf	0 psf	0 psf	Common Borrow
Slice 9	-59.819 ft	201.39611 ft	-1,229.0995 psf	349.35977 psf	218.30422 psf	0 psf	0 psf	Common Borrow
Slice 10	-57.479917 ft	202.34008 ft	-1,268.9454 psf	368.05015 psf	229.98326 psf	0 psf	0 psf	Common Borrow
Slice 11	-55.20775 ft	203.29294 ft	-1,305.014 psf	381.99289 psf	238.69565 psf	0 psf	0 psf	Common Borrow
Slice 12	-52.935583 ft	204.28125 ft	-1,343.2951 psf	391.92331 psf	244.90086 psf	0 psf	0 psf	Common Borrow
Slice 13	-50.663417 ft	205.30564 ft	-1,383.8274 psf	397.92392 psf	248.65046 psf	0 psf	0 psf	Common Borrow
Slice 14	-48.39125 ft	206.36676 ft	-1,426.6516 psf	400.07393 psf	249.99394 psf	0 psf	0 psf	Common Borrow
Slice 15	-46.119083 ft	207.4653 ft	-1,471.8113 psf	398.44941 psf	248.97883 psf	0 psf	0 psf	Common Borrow
Slice 16	-44.0025 ft	208.52171 ft	-1,518.9206 psf	393.7244 psf	246.02631 psf	0 psf	0 psf	Common Borrow
Slice	-42.0415 ft	209.53169	-1,567.7125	386.42025	241.46217	0 psf	0 psf	Common

17		ft	psf	psf	psf			Borrow
Slice 18	-40.0805 ft	210.57118 ft	-1,618.3454 psf	376.45239 psf	235.23356 psf	0 psf	0 psf	Common Borrow
Slice 19	-38.1 ft	211.65168 ft	-1,671.3956 psf	363.68324 psf	227.25451 psf	0 psf	0 psf	Common Borrow
Slice 20	-36.1 ft	212.7744 ft	-1,726.9393 psf	348.10704 psf	217.52142 psf	0 psf	0 psf	Common Borrow
Slice 21	-33.842 ft	214.08355 ft	-1,792.2439 psf	327.80444 psf	204.83494 psf	0 psf	0 psf	Common Borrow
Slice 22	-31.38225 ft	215.55493 ft	-1,864.8196 psf	302.77371 psf	189.19401 psf	0 psf	0 psf	Common Borrow
Slice 23	-28.97875 ft	217.04332 ft	-1,937.4775 psf	274.51518 psf	171.53612 psf	0 psf	0 psf	Common Borrow
Slice 24	-27.4385 ft	218.01785 ft	-1,983.8214 psf	255.00972 psf	159.34776 psf	0 psf	0 psf	Common Borrow
Slice 25	-26.205 ft	218.82146 ft	-2,018.0859 psf	237.20652 psf	148.22308 psf	0 psf	0 psf	Common Borrow
Slice 26	-24.30075 ft	220.08564 ft	-2,064.9027 psf	207.9765 psf	129.95814 psf	0 psf	0 psf	Common Borrow
Slice 27	-22.28225 ft	221.46163 ft	-2,109.6739 psf	174.71037 psf	109.17116 psf	0 psf	0 psf	Common Borrow
Slice 28	-20.077 ft	223.01169 ft	-2,144.3257 psf	135.45375 psf	84.640896 psf	0 psf	0 psf	Common Borrow
Slice 29	-17.8405 ft	224.6291 ft	-2,162.9888 psf	93.078686 psf	58.162018 psf	0 psf	0 psf	Common Borrow
Slice 30	-16.183443 ft	225.85792 ft	-2,174.7929 psf	36.235281 psf	22.642317 psf	0 psf	0 psf	Common Borrow

1B. Static (M-P)

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File Information

File Version: 11.02
Created By: Jon Cracolici
Last Edited By: Taylor Booker
Revision Number: 291
Date: 01/18/2022
Time: 05:50:42 AM
Tool Version: 11.2.2.23310
File Name: EMB I-405 SB MP 5.88.gsz
Directory: \\geoengineers.com\WAN\Projects\0\0180366\01\Analysis\EMB I-405 SB MP 5.97 to 5.83\01-18-22\
Last Solved Date: 01/18/2022
Last Solved Time: 05:52:00 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B. Static (M-P)

Description: Project Num: 00180-366-01 Embankment: EMB I-405 SB MP 5.97 to 5.83 Station: MP 5.88
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 4 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001

Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 15 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1A Loose to Med Dense Granular Fill (Original)

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Quarry Spalls

Slope Stability Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-86, 193.85013) ft
Left-Zone Right Coordinate: (-26, 221.6978) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (-19.583, 224.90784) ft
Right-Zone Right Coordinate: (60, 227.4) ft
Right-Zone Increment: 38
Radius Increments: 25

Slip Surface Limits

Left Coordinate: (-120, 183.7) ft
Right Coordinate: (60, 227.4) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-120 ft	171.9 ft

Coordinate 2	-103.2 ft	175.5 ft
Coordinate 3	-94.5 ft	177 ft
Coordinate 4	-92 ft	177.8 ft
Coordinate 5	-90.25762 ft	179.711 ft
Coordinate 6	-81.894 ft	180.175 ft
Coordinate 7	-65.834 ft	181.109 ft
Coordinate 8	-58.616 ft	181.817 ft
Coordinate 9	-44.983 ft	184.066 ft
Coordinate 10	-32.584 ft	185.508 ft
Coordinate 11	-27.777 ft	186.156 ft
Coordinate 12	-25.31 ft	186.665 ft
Coordinate 13	-21.273 ft	187.982 ft
Coordinate 14	-18.881 ft	189.313 ft
Coordinate 15	-13.948 ft	192.408 ft
Coordinate 16	-9.34 ft	198.085 ft
Coordinate 17	-7.036 ft	200.627 ft
Coordinate 18	-2.894 ft	203.633 ft
Coordinate 19	8.368 ft	210.024 ft
Coordinate 20	18.083 ft	214.581 ft
Coordinate 21	22.799 ft	216.342 ft
Coordinate 22	25.82 ft	217.166 ft
Coordinate 23	29.666 ft	217.984 ft
Coordinate 24	37.76 ft	218.338 ft
Coordinate 25	60 ft	219.309 ft

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	-3.5 ft	227.3 ft
	0.2 ft	227.6 ft
	37.7 ft	228.2 ft
	60 ft	228.4 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Point 1	60 ft	170 ft
Point 2	-4.3 ft	196.6 ft
Point 3	4 ft	225.3 ft
Point 4	-120 ft	170 ft
Point 5	0.2 ft	226.6 ft
Point 6	37.7 ft	227.2 ft
Point 7	-92.7 ft	193.2 ft
Point 8	-55.6 ft	196.8 ft
Point 9	-50 ft	199.6 ft
Point 10	-4.3 ft	225.7 ft
Point 11	-11.9 ft	219.8 ft
Point 12	-22.9 ft	213 ft
Point 13	-41.2 ft	203.1 ft
Point 14	-53.8 ft	193.9 ft
Point 15	-24.6 ft	205.1 ft
Point 16	-67.8 ft	191.1 ft
Point 17	-92 ft	177.8 ft
Point 18	-85 ft	187.7 ft
Point 19	-88.9 ft	181.2 ft
Point 20	-100.8 ft	190.8 ft
Point 21	-80.509 ft	194.38295 ft
Point 22	-16.8 ft	226.3 ft
Point 23	-35.1 ft	217.1 ft
Point 24	-35.1 ft	226.3 ft
Point 25	-53.2 ft	198.1 ft
Point 26	-78.51 ft	189.1 ft
Point 27	-7.6 ft	173.4 ft
Point 28	60 ft	185.2 ft
Point 29	60 ft	211.2 ft
Point 30	60 ft	225.3 ft
Point 31	-24.6 ft	195.3 ft
Point 32	-44.8 ft	190.9 ft
Point 33	-55.8 ft	188.8 ft
Point 34	-64.2 ft	187.5 ft
Point 35	-87.6 ft	183.3 ft
Point 36	-94.5 ft	177 ft
Point 37	-120 ft	171.9 ft
Point 38	60 ft	227.4 ft
Point 39	-69.1 ft	186.6 ft
Point 40	3.8 ft	225.4 ft
Point 41	-24.9 ft	196.1 ft
Point 42	-26.3 ft	195.8 ft
Point 43	-41.6 ft	192.6 ft
Point 44	-57 ft	189.2 ft
Point 45	-120 ft	183.7 ft
Point 46	0.9 ft	226.5 ft
Point 47	-11.6 ft	216.6 ft
Point 48	-19.6 ft	210.5 ft
Point 49	-24.7 ft	206.4 ft

Point 50	-28.6 ft	204.5 ft
Point 51	-41.7 ft	199.9 ft
Point 52	-53.6 ft	195.7 ft
Point 53	-46.7 ft	201 ft
Point 54	-111.255 ft	184.5 ft
Point 55	-103.2 ft	175.5 ft
Point 56	-105.5313 ft	188.8 ft
Point 57	-27.1 ft	226.3 ft
Point 58	-35.1 ft	215.1 ft
Point 59	-27.1 ft	221.14754 ft
Point 60	-39.1 ft	215.1 ft
Point 61	-120 ft	178.102 ft
Point 62	-107.308 ft	180.256 ft
Point 63	-35.1 ft	213.1 ft
Point 64	-27.1 ft	213.1 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	27,28,29,2	1,600.6 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,28,27,2,29,30,3,31,32,33,34,39,35,19,17,36,55,37,4	4,026.8 ft²
Region 3	Gravel Borrow	5,46,40,3,30,38,6	101.83 ft²
Region 4	ESU 2B Medium Dense Sand/Gravel	39,34,33,32,31,3,40,41,42,43,44	52.08 ft²
Region 5	Quarry Spalls	36,17,19,35,18,54,62,55	182.94 ft²
Region 6	Gravel Borrow	20,7,21,8,25,52,14,16,26,18,54,56	272.45 ft²
Region 7	ESU 1A Loose to Med Dense Granular Fill (Original)	5,46,47,48,49,50,51,52,25,9,53,13,12,11,10	199.45 ft²
Region 8	Common Borrow	5,22,59,64,63,58,60,21,8,25,9,53,13,12,11,10	544.6 ft²
Region 9	ESU 2A Very Loose to Loose Sand/Gravel	40,41,42,43,44,39,35,18,26,16,14,52,51,50,49,48,47,46	545.83 ft²
Region 10	Common Borrow	58,63,64,59,23	48.19 ft²
Region 11		22,57,59	26.535 ft²
Region 12	ESU 2A Very Loose to Loose Sand/Gravel	45,61,62,54	55.661 ft²
Region 13	ESU 4B Dense to Very Dense Sand/Gravel	61,37,55,62	86.703 ft²
Region 14		24,23,59,57	57.41 ft²
Region 15	Common Borrow	23,60,58	4 ft²

Slip Results

Slip Surfaces Analysed: 30079 of 31434 converged

Current Slip Surface

Slip Surface: 2,084
Factor of Safety: 1.27
Volume: 179.42814 ft³
Weight: 21,531.376 lbf
Resisting Moment: 2,269,199.4 lbf·ft
Activating Moment: 1,780,309.6 lbf·ft
Resisting Force: 10,845.204 lbf
Activating Force: 8,514.8169 lbf
Slip Rank: 1 of 31,434 slip surfaces
Exit: (-79.724166, 194.7756) ft
Entry: (-15.705632, 226.31931) ft
Radius: 187.08702 ft
Center: (-128.88693, 375.28759) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-78.732011 ft	195.0517 ft	-916.83097 psf	23.505992 psf	14.688174 psf	0 psf	0 psf	Common Borrow
Slice 2	-76.747702 ft	195.6157 ft	-944.82386 psf	69.776053 psf	43.600917 psf	0 psf	0 psf	Common Borrow
Slice 3	-74.763392 ft	196.20347 ft	-974.29953 psf	114.1201 psf	71.310155 psf	0 psf	0 psf	Common Borrow
Slice 4	-72.779083 ft	196.81523 ft	-1,005.2726 psf	156.18341 psf	97.594225 psf	0 psf	0 psf	Common Borrow
Slice 5	-70.794774 ft	197.45124 ft	-1,037.7586 psf	195.60858 psf	122.22981 psf	0 psf	0 psf	Common Borrow
Slice 6	-68.810464 ft	198.11176 ft	-1,071.7738 psf	232.05617 psf	145.00479 psf	0 psf	0 psf	Common Borrow
Slice 7	-66.826155 ft	198.79706 ft	-1,107.3353 psf	265.22358 psf	165.73008 psf	0 psf	0 psf	Common Borrow
Slice 8	-64.631 ft	199.58589 ft	-1,145.5945 psf	297.62607 psf	185.97741 psf	0 psf	0 psf	Common Borrow
Slice 9	-62.225 ft	200.48461 ft	-1,186.9482 psf	328.0714 psf	205.00176 psf	0 psf	0 psf	Common Borrow
Slice 10	-59.819 ft	201.42126 ft	-1,230.6692 psf	352.86066 psf	220.49181 psf	0 psf	0 psf	Common Borrow
Slice 11	-57.479917 ft	202.3683 ft	-1,270.7062 psf	371.57666 psf	232.18687 psf	0 psf	0 psf	Common Borrow
Slice 12	-55.20775 ft	203.32421 ft	-1,306.9654 psf	384.66443 psf	240.36501 psf	0 psf	0 psf	Common Borrow
Slice 13	-52.935583 ft	204.31566 ft	-1,345.4422 psf	392.9888 psf	245.56666 psf	0 psf	0 psf	Common Borrow
Slice 14	-50.663417 ft	205.34327 ft	-1,386.1756 psf	396.81864 psf	247.95981 psf	0 psf	0 psf	Common Borrow
Slice 15	-48.39125 ft	206.4077 ft	-1,429.2068 psf	396.46787 psf	247.74062 psf	0 psf	0 psf	Common Borrow
Slice	-46.119083	207.50966	-1,474.5794	392.26915	245.11697	0 psf	0 psf	Common

16	ft	ft	psf	psf	psf			Borrow
Slice 17	-44.0025 ft	208.56933 ft	-1,521.8924 psf	385.29989 psf	240.76209 psf	0 psf	0 psf	Common Borrow
Slice 18	-42.0415 ft	209.58243 ft	-1,570.8785 psf	376.21968 psf	235.08815 psf	0 psf	0 psf	Common Borrow
Slice 19	-40.0805 ft	210.62511 ft	-1,621.7108 psf	364.89436 psf	228.0113 psf	0 psf	0 psf	Common Borrow
Slice 20	-38.1 ft	211.70893 ft	-1,674.9679 psf	351.27516 psf	219.50108 psf	0 psf	0 psf	Common Borrow
Slice 21	-36.1 ft	212.83509 ft	-1,730.7266 psf	335.42917 psf	209.59941 psf	0 psf	0 psf	Common Borrow
Slice 22	-33.842 ft	214.14826 ft	-1,796.2819 psf	315.5699 psf	197.18996 psf	0 psf	0 psf	Common Borrow
Slice 23	-31.38225 ft	215.62417 ft	-1,869.14 psf	291.83876 psf	182.3611 psf	0 psf	0 psf	Common Borrow
Slice 24	-28.97875 ft	217.11715 ft	-1,942.0843 psf	265.54104 psf	165.92846 psf	0 psf	0 psf	Common Borrow
Slice 25	-27.4385 ft	218.09469 ft	-1,988.6162 psf	247.52339 psf	154.66978 psf	0 psf	0 psf	Common Borrow
Slice 26	-26.205 ft	218.9008 ft	-2,023.0365 psf	230.97751 psf	144.33077 psf	0 psf	0 psf	Common Borrow
Slice 27	-24.30075 ft	220.16891 ft	-2,070.0991 psf	203.62606 psf	127.23969 psf	0 psf	0 psf	Common Borrow
Slice 28	-22.28225 ft	221.54922 ft	-2,115.1394 psf	172.03635 psf	107.50024 psf	0 psf	0 psf	Common Borrow
Slice 29	-20.077 ft	223.10418 ft	-2,150.0966 psf	133.81111 psf	83.614463 psf	0 psf	0 psf	Common Borrow
Slice 30	-17.8405 ft	224.72673 ft	-2,169.0809 psf	91.150274 psf	56.957012 psf	0 psf	0 psf	Common Borrow
Slice 31	-16.252816 ft	225.90673 ft	-2,180.5549 psf	35.104117 psf	21.935487 psf	0 psf	0 psf	Common Borrow

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In Association with

Appendix K
Slope/W Reports – Compound Stability

1A.1 Compound - Static (Spencer)

Report generated using GeoStudio 2021 R2. Copyright © 1991-2021 GEOSLOPE International Ltd.

File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 650
Date: 01/17/2022
Time: 01:45:50 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 01:49:05 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.1 Compound - Static (Spencer)

Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb

Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (14.983919, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 5.0160809 ft
Required Length: 5.0160809 ft
Pullout Force: 3,478.3709 lbf
Pullout Force per Length: 693.44394 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5
Lock to Ground Surface: Yes

Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.588678, 196.1) ft
Max. Pullout Force: 7,860 lbf

Available Length: 2.4113217 ft
Required Length: 2.4113217 ft
Pullout Force: 1,832.5947 lbf
Pullout Force per Length: 759.99596 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft

Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft

Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²

Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 9745 of 11466 converged

Current Slip Surface

Slip Surface: 2,852
Factor of Safety: 1.3
Volume: 926.15021 ft³
Weight: 111,473.27 lbf
Resisting Moment: 3,612,669.1 lbf·ft
Activating Moment: 2,792,227.2 lbf·ft
Resisting Force: 56,229.62 lbf

Activating Force: 43,471.782 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (32.424307, 223.10874) ft
Radius: 52.811397 ft
Center: (-19.274577, 233.89155) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.48409 ft	-181.68176 psf	69.591423 psf	43.485547 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-29.25625 ft	182.04293 ft	-180.15416 psf	257.8555 psf	161.126 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-27.16875 ft	181.68417 ft	-178.93878 psf	472.73904 psf	295.40014 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-25.08125 ft	181.41086 ft	-178.88779 psf	646.2097 psf	403.79663 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-22.99375 ft	181.22167 ft	-179.14535 psf	786.17185 psf	491.25469 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-20.90625 ft	181.1157 ft	-177.96849 psf	898.38896 psf	561.37573 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-18.81875 ft	181.09244 ft	-176.75492 psf	987.16635 psf	616.85 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-16.73125 ft	181.15179 ft	-177.75218 psf	1,055.7875 psf	659.72925 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.64375 ft	181.29401 ft	-179.44633 psf	1,106.8015 psf	691.60636 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.65 ft	181.50604 ft	-184.2186 psf	1,164.3132 psf	727.54366 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-10.75 ft	181.78159 ft	-200.14219 psf	1,228.3695 psf	767.57043 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-8.85 ft	182.12832 ft	-294.87555 psf	1,278.325 psf	798.7861 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-6.95 ft	182.54767 ft	-362.48685 psf	1,388.2344 psf	867.46514 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 14	-5.521266 ft	182.90485 ft	-396.27515 psf	1,443.877 psf	902.23446 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

Slice 15	-3.781899 ft	183.42095 ft	-389.40397 psf	1,255.4769 psf	784.50904 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-1.260633 ft	184.26552 ft	-355.49357 psf	1,109.1323 psf	693.06278 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	0.6775 ft	184.9996 ft	-331.74593 psf	3,012.3532 psf	1,882.3272 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	2.2958333 ft	185.69717 ft	-312.89226 psf	2,858.8371 psf	1,786.3997 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	4.1775 ft	186.58467 ft	-292.03965 psf	2,760.0952 psf	1,724.6989 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	6.0591667 ft	187.56559 ft	-272.64084 psf	2,654.7246 psf	1,658.856 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.65178 ft	-254.49171 psf	2,541.9838 psf	1,588.4078 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	9.8958729 ft	189.88359 ft	-237.26176 psf	2,416.3601 psf	1,509.9094 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	11.887619 ft	191.27185 ft	-220.50564 psf	2,283.6536 psf	1,426.9851 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	13.227615 ft	192.26872 ft	-209.5233 psf	2,273.7015 psf	1,776.4103 psf	0 psf	0 psf	Gravel Borrow
Slice 25	14.285869 ft	193.12534 ft	-200.2752 psf	2,076.5959 psf	1,622.4145 psf	0 psf	0 psf	Gravel Borrow
Slice 26	15.25 ft	193.92922 ft	-190.94009 psf	1,995.0411 psf	1,558.6969 psf	0 psf	0 psf	Gravel Borrow
Slice 27	16 ft	194.59402 ft	-185.40797 psf	1,879.6808 psf	1,468.5676 psf	0 psf	0 psf	Gravel Borrow
Slice 28	17.50351 ft	196.0173 ft	-176.11263 psf	1,716.8318 psf	1,341.336 psf	0 psf	0 psf	Gravel Borrow
Slice 29	18.656323 ft	197.14588 ft	-172.10212 psf	1,589.6038 psf	1,241.9346 psf	0 psf	0 psf	Gravel Borrow
Slice 30	19.543751 ft	198.10056 ft	-176.31912 psf	1,503.2657 psf	1,174.4799 psf	0 psf	0 psf	Gravel Borrow
Slice 31	20.890939 ft	199.61482 ft	-189.41042 psf	1,371.6608 psf	1,071.6588 psf	0 psf	0 psf	Gravel Borrow
Slice 32	22.75 ft	201.97436 ft	-214.35342 psf	1,135.1803 psf	709.33937 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	24.25 ft	203.98403 ft	-237.06792 psf	992.64495 psf	620.27341 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	25.01513 ft	205.14142 ft	-254.02098 psf	897.66765 psf	560.925 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice		206.23572	-263.26581	812.19653	507.51672			ESU 2A Very

35	25.71513 ft	ft	psf	psf	psf	0 psf	0 psf	Loose to Loose Sand/Gravel
Slice 36	26.25 ft	207.13189 ft	-251.73198 psf	745.92615 psf	466.10639 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 37	27.772997 ft	210.0412 ft	-214.97451 psf	551.16542 psf	344.40638 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 38	30.11899 ft	215.50645 ft	-181.88356 psf	258.40327 psf	161.46829 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 39	31.595994 ft	219.75154 ft	0 psf	93.238487 psf	58.261873 psf	0 psf	0 psf	Common Borrow
Slice 40	32.162153 ft	221.97699 ft	0 psf	27.224015 psf	17.011452 psf	0 psf	0 psf	Common Borrow

1A.2 Compound - Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 650
Date: 01/17/2022
Time: 01:45:50 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 01:59:30 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.2 Compound - Static (M-P)

Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf

Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (14.983919, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 5.0160809 ft
Required Length: 5.0160809 ft
Pullout Force: 3,478.3709 lbf
Pullout Force per Length: 693.44394 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5

Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.588678, 196.1) ft

Max. Pullout Force: 7,860 lbf
Available Length: 2.4113217 ft
Required Length: 2.4113217 ft
Pullout Force: 1,832.5947 lbf
Pullout Force per Length: 759.99596 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft

Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft

Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²

Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 10925 of 11466 converged

Current Slip Surface

Slip Surface: 2,852
Factor of Safety: 1.3
Volume: 926.15021 ft³
Weight: 111,473.27 lbf
Resisting Moment: 3,610,085.7 lbf·ft
Activating Moment: 2,792,227.2 lbf·ft

Resisting Force: 56,114.321 lbf
Activating Force: 43,416.061 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (32.424307, 223.10874) ft
Radius: 52.811397 ft
Center: (-19.274577, 233.89155) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.48409 ft	-181.68176 psf	43.030043 psf	26.888155 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-29.25625 ft	182.04293 ft	-180.15416 psf	179.53902 psf	112.18843 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-27.16875 ft	181.68417 ft	-178.93878 psf	368.11373 psf	230.02299 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-25.08125 ft	181.41086 ft	-178.88779 psf	556.78167 psf	347.9158 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-22.99375 ft	181.22167 ft	-179.14535 psf	738.53006 psf	461.4848 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-20.90625 ft	181.1157 ft	-177.96849 psf	905.78236 psf	565.99563 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-18.81875 ft	181.09244 ft	-176.75492 psf	1,051.3784 psf	656.97412 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-16.73125 ft	181.15179 ft	-177.75218 psf	1,169.5394 psf	730.80932 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.64375 ft	181.29401 ft	-179.44633 psf	1,256.5893 psf	785.20417 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.65 ft	181.50604 ft	-184.2186 psf	1,333.5412 psf	833.28903 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-10.75 ft	181.78159 ft	-200.14219 psf	1,402.6138 psf	876.4504 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-8.85 ft	182.12832 ft	-294.87555 psf	1,444.6412 psf	902.712 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-6.95 ft	182.54767 ft	-362.48685 psf	1,556.9847 psf	972.91202 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice	-5.521266	182.90485	-396.27515	1,615.8917	1,009.7212	0 psf	0 psf	ESU 2A Very Loose to Loose

14	ft	ft	psf	psf	psf			Sand/Gravel
Slice 15	-3.781899 ft	183.42095 ft	-389.40397 psf	1,367.4624 psf	854.48535 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-1.260633 ft	184.26552 ft	-355.49357 psf	1,166.4006 psf	728.84796 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	0.6775 ft	184.9996 ft	-331.74593 psf	3,077.5638 psf	1,923.0753 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	2.2958333 ft	185.69717 ft	-312.89226 psf	2,863.1613 psf	1,789.1018 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	4.1775 ft	186.58467 ft	-292.03965 psf	2,712.0422 psf	1,694.6721 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	6.0591667 ft	187.56559 ft	-272.64084 psf	2,561.0481 psf	1,600.3205 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.65178 ft	-254.49171 psf	2,411.7877 psf	1,507.0522 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	9.8958729 ft	189.88359 ft	-237.26176 psf	2,260.2536 psf	1,412.3632 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	11.887619 ft	191.27185 ft	-220.50564 psf	2,115.6829 psf	1,322.0254 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	13.227615 ft	192.26872 ft	-209.5233 psf	2,117.4277 psf	1,654.3158 psf	0 psf	0 psf	Gravel Borrow
Slice 25	14.285869 ft	193.12534 ft	-200.2752 psf	1,909.8169 psf	1,492.1125 psf	0 psf	0 psf	Gravel Borrow
Slice 26	15.25 ft	193.92922 ft	-190.94009 psf	1,827.4012 psf	1,427.7223 psf	0 psf	0 psf	Gravel Borrow
Slice 27	16 ft	194.59402 ft	-185.40797 psf	1,717.191 psf	1,341.6166 psf	0 psf	0 psf	Gravel Borrow
Slice 28	17.50351 ft	196.0173 ft	-176.11263 psf	1,572.3485 psf	1,228.4533 psf	0 psf	0 psf	Gravel Borrow
Slice 29	18.656323 ft	197.14588 ft	-172.10212 psf	1,465.402 psf	1,144.8975 psf	0 psf	0 psf	Gravel Borrow
Slice 30	19.543751 ft	198.10056 ft	-176.31912 psf	1,396.5119 psf	1,091.0747 psf	0 psf	0 psf	Gravel Borrow
Slice 31	20.890939 ft	199.61482 ft	-189.41042 psf	1,293.9254 psf	1,010.9253 psf	0 psf	0 psf	Gravel Borrow
Slice 32	22.75 ft	201.97436 ft	-214.35342 psf	1,114.3532 psf	696.32516 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	24.25 ft	203.98403 ft	-237.06792 psf	1,013.7378 psf	633.45369 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	25.01513 ft	205.14142 ft	-254.02098 psf	937.56793 psf	585.85747 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 35	25.71513 ft	206.23572 ft	-263.26581 psf	867.92207 psf	542.3379 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 36	26.25 ft	207.13189 ft	-251.73198 psf	812.57863 psf	507.75548 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 37	27.772997 ft	210.0412 ft	-214.97451 psf	639.9921 psf	399.91145 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 38	30.11899 ft	215.50645 ft	-181.88356 psf	342.59516 psf	214.07722 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 39	31.595994 ft	219.75154 ft	0 psf	139.60161 psf	87.23277 psf	0 psf	0 psf	Common Borrow
Slice 40	32.162153 ft	221.97699 ft	0 psf	42.923206 psf	26.821396 psf	0 psf	0 psf	Common Borrow

1A.3 Compound - Pseudo-Static (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 650
Date: 01/17/2022
Time: 01:45:50 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 01:55:57 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.3 Compound - Pseudo-Static (Spencer)

Description: Project Num: 00180-366-01 Wall: 05.85L-A Station: 1+90
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Reinforcements

Row 1 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.4 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 9.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Row 8 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.193

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft

Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)(EQ)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (19.6, 193.7) ft
Length: 19.6 ft
Orientation: 0 °
Slip Surface Intersection: (16.500257, 193.7) ft
Max. Pullout Force: 10,480 lbf
Available Length: 3.0997429 ft
Required Length: 3.0997429 ft
Pullout Force: 2,883.2886 lbf
Pullout Force per Length: 930.17024 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf

Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)(EQ)
Lock to Ground Surface: Yes

Outside Point: (0, 196.1) ft
Inside Point: (19.6, 196.1) ft
Length: 19.6 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft

Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft

Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region	ESU 4B Dense to Very Dense	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8

12	Sand/Gravel		ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 7583 of 11466 converged

Current Slip Surface

Slip Surface: 2,972

Factor of Safety: 1.1
Volume: 1,089.4547 ft³
Weight: 131,373.28 lbf
Resisting Moment: 6,899,088.9 lbf·ft
Activating Moment: 6,225,832.8 lbf·ft
Resisting Force: 76,257.173 lbf
Activating Force: 68,809.653 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (44.738055, 223.23035) ft
Radius: 78.641419 ft
Center: (-24.267402, 260.94931) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.63197 ft	-181.69787 psf	281.36586 psf	175.8169 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-28.908333 ft	182.45733 ft	-179.8031 psf	440.21654 psf	275.07783 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 3	-26.125 ft	182.34216 ft	-178.31292 psf	650.61498 psf	406.54936 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 4	-23.341667 ft	182.32566 ft	-178.32011 psf	800.99872 psf	500.51955 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 5	-20.558333 ft	182.40777 ft	-177.3301 psf	906.92936 psf	566.71236 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 6	-17.775 ft	182.58879 ft	-176.47058 psf	979.13463 psf	611.83122 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-14.991667 ft	182.86942 ft	-176.62434 psf	1,025.1265 psf	640.57015 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
								ESU 2A Very

Slice 8	-12.333333 ft	183.22925 ft	-175.23349 psf	1,081.069 psf	675.5269 psf	100 psf	0 psf	Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-9.8 ft	183.66085 ft	-180.39959 psf	1,146.2015 psf	716.22619 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-7.2666667 ft	184.17845 ft	-238.51697 psf	1,192.3505 psf	745.06327 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 11	-4.6017274 ft	184.82016 ft	-303.95054 psf	1,207.3372 psf	754.42801 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 12	-1.8051822 ft	185.59818 ft	-358.26732 psf	1,051.2828 psf	656.9144 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 13	-0.20345477 ft	186.0804 ft	-374.77997 psf	1,426.9232 psf	891.64058 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	0.6775 ft	186.37241 ft	-362.92551 psf	2,921.4418 psf	1,825.5194 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	2.76625 ft	187.11574 ft	-334.76816 psf	2,715.9923 psf	1,697.1403 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	5.58875 ft	188.21173 ft	-297.17026 psf	2,582.6305 psf	1,613.8067 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	7.95 ft	189.21768 ft	-266.4414 psf	2,499.003 psf	1,561.5504 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	10.611532 ft	190.49163 ft	-233.63671 psf	2,332.4574 psf	1,457.4811 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 4B Dense to

Slice 19	12.661532 ft	191.51892 ft	-204.75428 psf	2,566.6254 psf	2,393.4169 psf	0 psf	0 psf	Very Dense Sand/Gravel
Slice 20	13.277044 ft	191.84947 ft	-192.3219 psf	2,575.3929 psf	2,401.5927 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	14.277044 ft	192.40655 ft	-172.11952 psf	2,242.0754 psf	1,751.7013 psf	0 psf	0 psf	Gravel Borrow
Slice 22	15.25 ft	192.9584 ft	-149.2578 psf	2,368.913 psf	1,850.7977 psf	0 psf	0 psf	Gravel Borrow
Slice 23	16 ft	193.40177 ft	-137.38527 psf	2,177.0271 psf	1,700.88 psf	0 psf	0 psf	Gravel Borrow
Slice 24	17.50351 ft	194.32904 ft	-116.39919 psf	2,011.4624 psf	1,571.5267 psf	0 psf	0 psf	Gravel Borrow
Slice 25	19.25351 ft	195.45428 ft	-101.25132 psf	1,837.7176 psf	1,435.7823 psf	0 psf	0 psf	Gravel Borrow
Slice 26	20.75 ft	196.47397 ft	-92.486908 psf	1,746.4961 psf	1,364.5123 psf	0 psf	0 psf	Gravel Borrow
Slice 27	22.75 ft	197.93023 ft	-82.637841 psf	1,529.3482 psf	1,426.1402 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	24.25 ft	199.05882 ft	-79.331138 psf	1,439.4105 psf	1,342.272 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	25.2 ft	199.82127 ft	-78.129103 psf	1,356.8302 psf	1,265.2646 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	26.25 ft	200.68111 ft	-77.908915 psf	1,268.2622 psf	1,182.6736 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	27.925 ft	202.15061 ft	-77.837572 psf	1,129.3615 psf	1,053.1467 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	30.575 ft	204.61669 ft	-84.964815 psf	920.89922 psf	858.75241 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	32.9 ft	206.96562 ft	-99.671373 psf	746.94451 psf	696.53702 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	34.9 ft	209.16721 ft	-123.43094 psf	602.46768 psf	561.8102 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	36.9 ft	211.54801 ft	-164.66922 psf	514.6925 psf	479.95852 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	38.65 ft	213.78672 ft	-228.53372 psf	396.84403 psf	370.06304 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	39.8 ft	215.34926 ft	-286.83402 psf	323.3106 psf	301.49201 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	41 ft	217.10207 ft	-369.13159 psf	254.33046 psf	237.16699 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel

Slice 39	42.19125 ft	218.91142 ft	-478.68475 psf	191.45321 psf	178.53301 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	42.681662 ft	219.69086 ft	-531.43838 psf	164.00281 psf	152.9351 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	43.759439 ft	221.54106 ft	0 psf	97.227797 psf	75.96268 psf	0 psf	0 psf	Gravel Borrow

1A.4 Compound - Pseudo-Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 650
Date: 01/17/2022
Time: 01:45:50 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:01:23 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.4 Compound - Pseudo-Static (M-P)

Description: Project Num: 00180-366-01 Wall: 05.85L-A Station: 1+90
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Reinforcements

Row 1 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.4 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 9.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Row 8 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.193

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft

Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)(EQ)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (19.6, 193.7) ft
Length: 19.6 ft
Orientation: 0 °
Slip Surface Intersection: (16.500257, 193.7) ft
Max. Pullout Force: 10,480 lbf
Available Length: 3.0997429 ft
Required Length: 3.0997429 ft
Pullout Force: 2,883.2886 lbf
Pullout Force per Length: 930.17024 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf

Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)(EQ)
Lock to Ground Surface: Yes

Outside Point: (0, 196.1) ft
Inside Point: (19.6, 196.1) ft
Length: 19.6 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft

Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft

Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region	ESU 4B Dense to Very Dense	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8

12	Sand/Gravel		ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 10196 of 11466 converged

Current Slip Surface

Slip Surface: 2,972

Factor of Safety: 1.1
Volume: 1,089.4547 ft³
Weight: 131,373.28 lbf
Resisting Moment: 6,860,180.7 lbf·ft
Activating Moment: 6,225,832.8 lbf·ft
Resisting Force: 75,821.94 lbf
Activating Force: 68,834.441 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (44.738055, 223.23035) ft
Radius: 78.641419 ft
Center: (-24.267402, 260.94931) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.63197 ft	-181.69787 psf	40.746197 psf	25.46105 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-28.908333 ft	182.45733 ft	-179.8031 psf	176.9578 psf	110.57551 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 3	-26.125 ft	182.34216 ft	-178.31292 psf	396.53087 psf	247.77999 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 4	-23.341667 ft	182.32566 ft	-178.32011 psf	624.03133 psf	389.93805 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 5	-20.558333 ft	182.40777 ft	-177.3301 psf	846.09089 psf	528.69627 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 6	-17.775 ft	182.58879 ft	-176.47058 psf	1,045.3991 psf	653.23783 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-14.991667 ft	182.86942 ft	-176.62434 psf	1,204.3962 psf	752.59028 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
								ESU 2A Very

Slice 8	-12.333333 ft	183.22925 ft	-175.23349 psf	1,337.7146 psf	835.89684 psf	100 psf	0 psf	Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-9.8 ft	183.66085 ft	-180.39959 psf	1,442.9374 psf	901.64737 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-7.2666667 ft	184.17845 ft	-238.51697 psf	1,494.8196 psf	934.06697 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 11	-4.6017274 ft	184.82016 ft	-303.95054 psf	1,496.0889 psf	934.86011 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 12	-1.8051822 ft	185.59818 ft	-358.26732 psf	1,287.1517 psf	804.30165 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 13	-0.20345477 ft	186.0804 ft	-374.77997 psf	1,754.6737 psf	1,096.4418 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	0.6775 ft	186.37241 ft	-362.92551 psf	3,144.6847 psf	1,965.0171 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	2.76625 ft	187.11574 ft	-334.76816 psf	2,844.0203 psf	1,777.1411 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	5.58875 ft	188.21173 ft	-297.17026 psf	2,607.5404 psf	1,629.372 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	7.95 ft	189.21768 ft	-266.4414 psf	2,453.8152 psf	1,533.3139 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	10.611532 ft	190.49163 ft	-233.63671 psf	2,208.5134 psf	1,380.0323 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 4B Dense to

Slice 19	12.661532 ft	191.51892 ft	-204.75428 psf	2,509.9725 psf	2,340.5872 psf	0 psf	0 psf	Very Dense Sand/Gravel
Slice 20	13.277044 ft	191.84947 ft	-192.3219 psf	2,507.2379 psf	2,338.0372 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 21	14.277044 ft	192.40655 ft	-172.11952 psf	2,067.1419 psf	1,615.0282 psf	0 psf	0 psf	Gravel Borrow
Slice 22	15.25 ft	192.9584 ft	-149.2578 psf	2,212.9823 psf	1,728.9713 psf	0 psf	0 psf	Gravel Borrow
Slice 23	16 ft	193.40177 ft	-137.38527 psf	1,985.1173 psf	1,550.9436 psf	0 psf	0 psf	Gravel Borrow
Slice 24	17.50351 ft	194.32904 ft	-116.39919 psf	1,800.587 psf	1,406.7727 psf	0 psf	0 psf	Gravel Borrow
Slice 25	19.25351 ft	195.45428 ft	-101.25132 psf	1,625.3662 psf	1,269.8753 psf	0 psf	0 psf	Gravel Borrow
Slice 26	20.75 ft	196.47397 ft	-92.486908 psf	1,550.3738 psf	1,211.2848 psf	0 psf	0 psf	Gravel Borrow
Slice 27	22.75 ft	197.93023 ft	-82.637841 psf	1,355.2136 psf	1,263.7571 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	24.25 ft	199.05882 ft	-79.331138 psf	1,284.5881 psf	1,197.8978 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	25.2 ft	199.82127 ft	-78.129103 psf	1,217.1699 psf	1,135.0293 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	26.25 ft	200.68111 ft	-77.908915 psf	1,146.5418 psf	1,069.1675 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	27.925 ft	202.15061 ft	-77.837572 psf	1,039.4081 psf	969.26373 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	30.575 ft	204.61669 ft	-84.964815 psf	882.32469 psf	822.78108 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	32.9 ft	206.96562 ft	-99.671373 psf	750.83822 psf	700.16797 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 34	34.9 ft	209.16721 ft	-123.43094 psf	637.21432 psf	594.21196 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	36.9 ft	211.54801 ft	-164.66922 psf	576.92388 psf	537.99022 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	38.65 ft	213.78672 ft	-228.53372 psf	471.23986 psf	439.43828 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	39.8 ft	215.34926 ft	-286.83402 psf	400.0565 psf	373.05873 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	41 ft	217.10207 ft	-369.13159 psf	329.58965 psf	307.34732 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel

Slice 39	42.19125 ft	218.91142 ft	-478.68475 psf	260.66228 psf	243.07151 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	42.681662 ft	219.69086 ft	-531.43838 psf	227.64835 psf	212.28552 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 41	43.759439 ft	221.54106 ft	0 psf	146.90679 psf	114.77617 psf	0 psf	0 psf	Gravel Borrow

1A.5 Compound - Post-Seismic (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 650
Date: 01/17/2022
Time: 01:45:50 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 01:58:32 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.5 Compound - Post-Seismic (Spencer)

Description: Project Num: 00180-366-01 Wall: 05.85L-A Station: 1+90
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 110 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt
- Material Model: Mohr-Coulomb
- Unit Weight: 130 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 43 °
- Phi-B: 0 °

Common Borrow
- Material Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Effective Cohesion: 0 psf
- Effective Friction Angle: 32 °
- Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1

Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic

Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft

Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (14.983919, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 5.0160809 ft
Required Length: 5.0160809 ft
Pullout Force: 3,478.3709 lbf
Pullout Force per Length: 693.44394 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.588678, 196.1) ft
Max. Pullout Force: 7,860 lbf
Available Length: 2.4113217 ft
Required Length: 2.4113217 ft
Pullout Force: 1,832.5947 lbf
Pullout Force per Length: 759.99596 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft

Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft

Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²

Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 9780 of 11466 converged

Current Slip Surface

Slip Surface: 2,852
Factor of Safety: 1.3
Volume: 926.15021 ft³
Weight: 111,473.27 lbf
Resisting Moment: 3,612,669.1 lbf·ft
Activating Moment: 2,792,227.2 lbf·ft
Resisting Force: 56,229.62 lbf
Activating Force: 43,471.782 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (32.424307, 223.10874) ft
Radius: 52.811397 ft
Center: (-19.274577, 233.89155) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.48409 ft	-181.68176 psf	69.591423 psf	43.485547 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-29.25625 ft	182.04293 ft	-180.15416 psf	257.8555 psf	161.126 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-27.16875 ft	181.68417 ft	-178.93878 psf	472.73904 psf	295.40014 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-25.08125 ft	181.41086 ft	-178.88779 psf	646.2097 psf	403.79663 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-22.99375 ft	181.22167 ft	-179.14535 psf	786.17185 psf	491.25469 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-20.90625 ft	181.1157 ft	-177.96849 psf	898.38896 psf	561.37573 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-18.81875 ft	181.09244 ft	-176.75492 psf	987.16635 psf	616.85 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-16.73125 ft	181.15179 ft	-177.75218 psf	1,055.7875 psf	659.72925 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.64375 ft	181.29401 ft	-179.44633 psf	1,106.8015 psf	691.60636 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.65 ft	181.50604 ft	-184.2186 psf	1,164.3132 psf	727.54366 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-10.75 ft	181.78159 ft	-200.14219 psf	1,228.3695 psf	767.57043 psf	0 psf	0 psf	ESU 2A Very Loose to Loose

								Sand/Gravel
Slice 12	-8.85 ft	182.12832 ft	-294.87555 psf	1,278.325 psf	798.7861 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-6.95 ft	182.54767 ft	-362.48685 psf	1,388.2344 psf	867.46514 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 14	-5.521266 ft	182.90485 ft	-396.27515 psf	1,443.877 psf	902.23446 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 15	-3.781899 ft	183.42095 ft	-389.40397 psf	1,255.4769 psf	784.50904 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-1.260633 ft	184.26552 ft	-355.49357 psf	1,109.1323 psf	693.06278 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	0.6775 ft	184.9996 ft	-331.74593 psf	3,012.3532 psf	1,882.3272 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	2.2958333 ft	185.69717 ft	-312.89226 psf	2,858.8371 psf	1,786.3997 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	4.1775 ft	186.58467 ft	-292.03965 psf	2,760.0952 psf	1,724.6989 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	6.0591667 ft	187.56559 ft	-272.64084 psf	2,654.7246 psf	1,658.856 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.65178 ft	-254.49171 psf	2,541.9838 psf	1,588.4078 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	9.8958729 ft	189.88359 ft	-237.26176 psf	2,416.3601 psf	1,509.9094 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	11.887619 ft	191.27185 ft	-220.50564 psf	2,283.6536 psf	1,426.9851 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	13.227615 ft	192.26872 ft	-209.5233 psf	2,273.7015 psf	1,776.4103 psf	0 psf	0 psf	Gravel Borrow
Slice 25	14.285869 ft	193.12534 ft	-200.2752 psf	2,076.5959 psf	1,622.4145 psf	0 psf	0 psf	Gravel Borrow
Slice 26	15.25 ft	193.92922 ft	-190.94009 psf	1,995.0411 psf	1,558.6969 psf	0 psf	0 psf	Gravel Borrow
Slice 27	16 ft	194.59402 ft	-185.40797 psf	1,879.6808 psf	1,468.5676 psf	0 psf	0 psf	Gravel Borrow
Slice 28	17.50351 ft	196.0173 ft	-176.11263 psf	1,716.8318 psf	1,341.336 psf	0 psf	0 psf	Gravel Borrow
Slice 29	18.656323 ft	197.14588 ft	-172.10212 psf	1,589.6038 psf	1,241.9346 psf	0 psf	0 psf	Gravel Borrow
Slice 30	19.543751 ft	198.10056 ft	-176.31912 psf	1,503.2657 psf	1,174.4799 psf	0 psf	0 psf	Gravel Borrow
Slice 31	20.890939 ft	199.61482 ft	-189.41042 psf	1,371.6608 psf	1,071.6588 psf	0 psf	0 psf	Gravel Borrow

Slice 32	22.75 ft	201.97436 ft	-214.35342 psf	1,135.1803 psf	709.33937 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	24.25 ft	203.98403 ft	-237.06792 psf	992.64495 psf	620.27341 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	25.01513 ft	205.14142 ft	-254.02098 psf	897.66765 psf	560.925 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	25.71513 ft	206.23572 ft	-263.26581 psf	812.19653 psf	507.51672 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 36	26.25 ft	207.13189 ft	-251.73198 psf	745.92615 psf	466.10639 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 37	27.772997 ft	210.0412 ft	-214.97451 psf	551.16542 psf	344.40638 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 38	30.11899 ft	215.50645 ft	-181.88356 psf	258.40327 psf	161.46829 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 39	31.595994 ft	219.75154 ft	0 psf	93.238487 psf	58.261873 psf	0 psf	0 psf	Common Borrow
Slice 40	32.162153 ft	221.97699 ft	0 psf	27.224015 psf	17.011452 psf	0 psf	0 psf	Common Borrow

1A.6 Compound - Post-Seismic (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 650
Date: 01/17/2022
Time: 01:45:50 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:00:26 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.6 Compound - Post-Seismic (M-P)

Description: Project Num: 00180-366-01 Wall: 05.85L-A Station: 1+90
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2

Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 218.535) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes

Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (14.983919, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 5.0160809 ft
Required Length: 5.0160809 ft
Pullout Force: 3,478.3709 lbf
Pullout Force per Length: 693.44394 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.588678, 196.1) ft
Max. Pullout Force: 7,860 lbf
Available Length: 2.4113217 ft
Required Length: 2.4113217 ft
Pullout Force: 1,832.5947 lbf
Pullout Force per Length: 759.99596 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	35.9 ft	224.15 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft

Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft

Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Common Borrow	38,37,62,64	38.52 ft²
Region 8	Common Borrow	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region	ESU 4B Dense to Very Dense		4,704.7

10	Sand/Gravel	44,54,45,1,43,3,47,48	ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15		63,36,62	20.093 ft²
Region 16		36,35,64,62	51.88 ft²
Region 17	Common Borrow	64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 10931 of 11466 converged

Current Slip Surface

Slip Surface: 2,852
Factor of Safety: 1.3
Volume: 926.15021 ft³
Weight: 111,473.27 lbf
Resisting Moment: 3,610,085.7 lbf·ft
Activating Moment: 2,792,227.2 lbf·ft
Resisting Force: 56,114.321 lbf
Activating Force: 43,416.061 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (32.424307, 223.10874) ft
Radius: 52.811397 ft
Center: (-19.274577, 233.89155) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.48409 ft	-181.68176 psf	43.030043 psf	26.888155 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-29.25625 ft	182.04293 ft	-180.15416 psf	179.53902 psf	112.18843 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-27.16875 ft	181.68417 ft	-178.93878 psf	368.11373 psf	230.02299 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-25.08125 ft	181.41086 ft	-178.88779 psf	556.78167 psf	347.9158 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-22.99375 ft	181.22167 ft	-179.14535 psf	738.53006 psf	461.4848 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-20.90625 ft	181.1157 ft	-177.96849 psf	905.78236 psf	565.99563 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-18.81875 ft	181.09244 ft	-176.75492 psf	1,051.3784 psf	656.97412 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-16.73125 ft	181.15179 ft	-177.75218 psf	1,169.5394 psf	730.80932 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-14.64375 ft	181.29401 ft	-179.44633 psf	1,256.5893 psf	785.20417 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-12.65 ft	181.50604 ft	-184.2186 psf	1,333.5412 psf	833.28903 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
								ESU 2A Very

Slice 11	-10.75 ft	181.78159 ft	-200.14219 psf	1,402.6138 psf	876.4504 psf	0 psf	0 psf	Loose to Loose Sand/Gravel
Slice 12	-8.85 ft	182.12832 ft	-294.87555 psf	1,444.6412 psf	902.712 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-6.95 ft	182.54767 ft	-362.48685 psf	1,556.9847 psf	972.91202 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 14	-5.521266 ft	182.90485 ft	-396.27515 psf	1,615.8917 psf	1,009.7212 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 15	-3.781899 ft	183.42095 ft	-389.40397 psf	1,367.4624 psf	854.48535 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-1.260633 ft	184.26552 ft	-355.49357 psf	1,166.4006 psf	728.84796 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	0.6775 ft	184.9996 ft	-331.74593 psf	3,077.5638 psf	1,923.0753 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	2.2958333 ft	185.69717 ft	-312.89226 psf	2,863.1613 psf	1,789.1018 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	4.1775 ft	186.58467 ft	-292.03965 psf	2,712.0422 psf	1,694.6721 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	6.0591667 ft	187.56559 ft	-272.64084 psf	2,561.0481 psf	1,600.3205 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.65178 ft	-254.49171 psf	2,411.7877 psf	1,507.0522 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	9.8958729 ft	189.88359 ft	-237.26176 psf	2,260.2536 psf	1,412.3632 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	11.887619 ft	191.27185 ft	-220.50564 psf	2,115.6829 psf	1,322.0254 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	13.227615 ft	192.26872 ft	-209.5233 psf	2,117.4277 psf	1,654.3158 psf	0 psf	0 psf	Gravel Borrow
Slice 25	14.285869 ft	193.12534 ft	-200.2752 psf	1,909.8169 psf	1,492.1125 psf	0 psf	0 psf	Gravel Borrow
Slice 26	15.25 ft	193.92922 ft	-190.94009 psf	1,827.4012 psf	1,427.7223 psf	0 psf	0 psf	Gravel Borrow
Slice 27	16 ft	194.59402 ft	-185.40797 psf	1,717.191 psf	1,341.6166 psf	0 psf	0 psf	Gravel Borrow
Slice 28	17.50351 ft	196.0173 ft	-176.11263 psf	1,572.3485 psf	1,228.4533 psf	0 psf	0 psf	Gravel Borrow
Slice 29	18.656323 ft	197.14588 ft	-172.10212 psf	1,465.402 psf	1,144.8975 psf	0 psf	0 psf	Gravel Borrow
Slice 30	19.543751 ft	198.10056 ft	-176.31912 psf	1,396.5119 psf	1,091.0747 psf	0 psf	0 psf	Gravel Borrow
Slice	20.890939	199.61482	-189.41042	1,293.9254	1,010.9253			

31	ft	ft	psf	psf	psf	0 psf	0 psf	Gravel Borrow
Slice 32	22.75 ft	201.97436 ft	-214.35342 psf	1,114.3532 psf	696.32516 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	24.25 ft	203.98403 ft	-237.06792 psf	1,013.7378 psf	633.45369 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	25.01513 ft	205.14142 ft	-254.02098 psf	937.56793 psf	585.85747 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	25.71513 ft	206.23572 ft	-263.26581 psf	867.92207 psf	542.3379 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 36	26.25 ft	207.13189 ft	-251.73198 psf	812.57863 psf	507.75548 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 37	27.772997 ft	210.0412 ft	-214.97451 psf	639.9921 psf	399.91145 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 38	30.11899 ft	215.50645 ft	-181.88356 psf	342.59516 psf	214.07722 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 39	31.595994 ft	219.75154 ft	0 psf	139.60161 psf	87.23277 psf	0 psf	0 psf	Common Borrow
Slice 40	32.162153 ft	221.97699 ft	0 psf	42.923206 psf	26.821396 psf	0 psf	0 psf	Common Borrow

1B.1 Compound - Static FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
Time: 02:07:09 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:37:20 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.1 Compound - Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic

Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (15.079752, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 4.9202484 ft
Required Length: 4.9202484 ft
Pullout Force: 3,010.1026 lbf
Pullout Force per Length: 611.77858 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft

Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf

Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.823618, 196.1) ft
Max. Pullout Force: 7,860 lbf
Available Length: 2.1763818 ft
Required Length: 2.1763818 ft
Pullout Force: 1,407.5924 lbf
Pullout Force per Length: 646.75803 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224.75 ft
	19.995 ft	224.75 ft
	20 ft	224 ft
	26 ft	224 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft

Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft

Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region	Forward Compatible Wall	38,37,62,64	38.52

7			ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region		55,39,58	11.1 ft²

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Slip Results

Slip Surfaces Analysed: 6769 of 11466 converged

Current Slip Surface

Slip Surface: 1,107
Factor of Safety: 1.3
Volume: 1,073.6112 ft³
Weight: 111,807.65 lbf
Resisting Moment: 4,586,543.7 lbf·ft
Activating Moment: 3,447,161.1 lbf·ft
Resisting Force: 61,881.24 lbf
Activating Force: 46,517.32 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-40.78762, 181.90624) ft
Entry: (34.999735, 223.15166) ft
Radius: 62.096408 ft
Center: (-24.243501, 241.75819) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-39.04381 ft	181.47809 ft	-184.62609 psf	126.77147 psf	79.215604 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	180.8223 ft	-184.06914 psf	294.14797 psf	183.80405 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.41291 ft	-182.77569 psf	383.5427 psf	239.66408 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-31.466667 ft	180.0945 ft	-181.51734 psf	448.27608 psf	280.11398 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-29.107143 ft	179.86411 ft	-179.81086 psf	558.64631 psf	349.08096 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.721429 ft	179.72272 ft	-178.81296 psf	707.59718 psf	442.15579 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-24.335714 ft	179.67331 ft	-179.75536 psf	829.5393 psf	518.35368 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-21.95 ft	179.71563 ft	-179.27882 psf	928.04363 psf	579.90602 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

Slice 9	-19.564286 ft	179.84989 ft	-177.12713 psf	1,005.926 psf	628.57233 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-17.178571 ft	180.07667 ft	-181.32295 psf	1,065.4365 psf	665.75862 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-14.792857 ft	180.39702 ft	-186.651 psf	1,108.3939 psf	692.60138 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-12.339565 ft	180.82699 ft	-200.67145 psf	1,164.7726 psf	727.8307 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-9.8186957 ft	181.37434 ft	-296.88615 psf	1,231.4977 psf	769.52515 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 14	-7.2791304 ft	182.0388 ft	-383.76897 psf	1,279.8958 psf	799.76769 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 15	-5.5625 ft	182.54017 ft	-404.88014 psf	1,393.8296 psf	870.96139 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-3.84375 ft	183.12395 ft	-383.82621 psf	1,221.322 psf	763.16669 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	-1.28125 ft	184.07979 ft	-351.82381 psf	1,079.6558 psf	674.64383 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	0.6775 ft	184.88675 ft	-329.17673 psf	2,911.4998 psf	1,819.307 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	2.76625 ft	185.86561 ft	-306.5904 psf	2,671.3396 psf	1,669.2382 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	5.58875 ft	187.32097 ft	-277.57173 psf	2,420.9606 psf	1,512.7841 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.67045 ft	-254.88611 psf	3,320.8837 psf	2,075.1184 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	8.95 ft	189.27817 ft	-245.58458 psf	4,364.2179 psf	2,727.066 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	9.9765041 ft	189.95485 ft	-236.93585 psf	3,408.8056 psf	2,130.0581 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	11.929512 ft	191.29995 ft	-220.10199 psf	3,181.9857 psf	1,988.3254 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	13.143619 ft	192.17917 ft	-209.68292 psf	3,149.6607 psf	2,460.7846 psf	0 psf	0 psf	Gravel Borrow
Slice 26	14.190611 ft	192.99631 ft	-199.12368 psf	2,848.6766 psf	2,225.6301 psf	0 psf	0 psf	Gravel Borrow
Slice 27	15.25 ft	193.84032 ft	-186.82298 psf	1,971.9784 psf	1,540.6784 psf	0 psf	0 psf	Gravel Borrow

Slice 28	16 ft	194.4719 ft	-180.08144 psf	1,715.7156 psf	1,340.4639 psf	0 psf	0 psf	Gravel Borrow
Slice 29	17.50351 ft	195.80917 ft	-167.99769 psf	1,533.662 psf	1,198.2281 psf	0 psf	0 psf	Gravel Borrow
Slice 30	18.807976 ft	197.01045 ft	-161.36396 psf	1,377.9082 psf	1,076.5399 psf	0 psf	0 psf	Gravel Borrow
Slice 31	19.551966 ft	197.7408 ft	-160.21572 psf	1,297.4264 psf	1,013.6606 psf	0 psf	0 psf	Gravel Borrow
Slice 32	19.9975 ft	198.18414 ft	-162.27411 psf	1,197.7547 psf	935.78856 psf	0 psf	0 psf	Gravel Borrow
Slice 33	20.75 ft	198.97543 ft	-167.4718 psf	1,065.6579 psf	832.58322 psf	0 psf	0 psf	Gravel Borrow
Slice 34	22.364152 ft	200.74625 ft	-188.63507 psf	786.70251 psf	733.61196 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	23.614152 ft	202.19505 ft	-203.72234 psf	784.16151 psf	489.9985 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	24.25 ft	202.97438 ft	-211.31843 psf	748.85109 psf	467.93409 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	25.2 ft	204.20869 ft	-225.83795 psf	695.23097 psf	434.42853 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	25.95 ft	205.19907 ft	-239.25229 psf	653.75372 psf	408.51066 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 39	26.3 ft	205.68809 ft	-246.35413 psf	632.98265 psf	395.53146 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 40	27.286631 ft	207.13025 ft	-268.80823 psf	570.22897 psf	356.31861 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 41	28.954947 ft	209.78543 ft	-262.03638 psf	457.07376 psf	285.61139 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 42	30.918316 ft	213.32322 ft	-217.03131 psf	316.93103 psf	198.04049 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 43	33.022443 ft	217.92455 ft	-189.37484 psf	278.7332 psf	174.17183 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 44	34.572311 ft	221.88658 ft	0 psf	111.00891 psf	69.366063 psf	0 psf	0 psf	Common Borrow

1B.2 Compound - Static FC Wall (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
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Time: 02:07:09 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:30:57 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.2 Compound - Static FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (15.079752, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 4.9202484 ft
Required Length: 4.9202484 ft
Pullout Force: 3,010.1026 lbf
Pullout Force per Length: 611.77858 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft

Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.823618, 196.1) ft
Max. Pullout Force: 7,860 lbf
Available Length: 2.1763818 ft
Required Length: 2.1763818 ft
Pullout Force: 1,407.5924 lbf
Pullout Force per Length: 646.75803 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224.75 ft
	19.995 ft	224.75 ft
	20 ft	224 ft
	26 ft	224 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft

Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft

Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²

Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²

Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 8873 of 11466 converged

Current Slip Surface

Slip Surface: 1,107
Factor of Safety: 1.3
Volume: 1,073.6112 ft³
Weight: 111,807.65 lbf
Resisting Moment: 4,583,873.8 lbf·ft
Activating Moment: 3,447,161.1 lbf·ft
Resisting Force: 61,795.166 lbf
Activating Force: 46,487.672 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-40.78762, 181.90624) ft
Entry: (34.999735, 223.15166) ft
Radius: 62.096408 ft
Center: (-24.243501, 241.75819) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-39.04381 ft	181.47809 ft	-184.62609 psf	83.846124 psf	52.392873 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	180.8223 ft	-184.06914 psf	221.22597 psf	138.23733 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.41291 ft	-182.77569 psf	319.29972 psf	199.52061 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-31.466667 ft	180.0945 ft	-181.51734 psf	407.89652 psf	254.88204 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-29.107143 ft	179.86411 ft	-179.81086 psf	542.67243 psf	339.09937 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.721429 ft	179.72272 ft	-178.81296 psf	721.15928 psf	450.63033 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 7	-24.335714 ft	179.67331 ft	-179.75536 psf	880.05631 psf	549.92022 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-21.95 ft	179.71563 ft	-179.27882 psf	1,014.1903 psf	633.73644 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

Slice 9	-19.564286 ft	179.84989 ft	-177.12713 psf	1,120.0786 psf	699.90278 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-17.178571 ft	180.07667 ft	-181.32295 psf	1,196.1905 psf	747.46279 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-14.792857 ft	180.39702 ft	-186.651 psf	1,242.8981 psf	776.64891 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-12.339565 ft	180.82699 ft	-200.67145 psf	1,291.1263 psf	806.78526 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-9.8186957 ft	181.37434 ft	-296.88615 psf	1,338.8829 psf	836.62688 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 14	-7.2791304 ft	182.0388 ft	-383.76897 psf	1,358.9767 psf	849.18291 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 15	-5.5625 ft	182.54017 ft	-404.88014 psf	1,488.9709 psf	930.41231 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-3.84375 ft	183.12395 ft	-383.82621 psf	1,264.2751 psf	790.00675 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	-1.28125 ft	184.07979 ft	-351.82381 psf	1,083.1659 psf	676.8372 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	0.6775 ft	184.88675 ft	-329.17673 psf	2,913.4691 psf	1,820.5375 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	2.76625 ft	185.86561 ft	-306.5904 psf	2,618.8727 psf	1,636.4533 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	5.58875 ft	187.32097 ft	-277.57173 psf	2,328.5567 psf	1,455.0437 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.67045 ft	-254.88611 psf	3,201.6566 psf	2,000.6171 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	8.95 ft	189.27817 ft	-245.58458 psf	4,404.3023 psf	2,752.1135 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	9.9765041 ft	189.95485 ft	-236.93585 psf	3,276.9863 psf	2,047.6883 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	11.929512 ft	191.29995 ft	-220.10199 psf	3,056.3477 psf	1,909.818 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	13.143619 ft	192.17917 ft	-209.68292 psf	3,041.9259 psf	2,376.613 psf	0 psf	0 psf	Gravel Borrow
Slice 26	14.190611 ft	192.99631 ft	-199.12368 psf	2,738.5435 psf	2,139.5846 psf	0 psf	0 psf	Gravel Borrow
Slice 27	15.25 ft	193.84032 ft	-186.82298 psf	1,857.3307 psf	1,451.1058 psf	0 psf	0 psf	Gravel Borrow

Slice 28	16 ft	194.4719 ft	-180.08144 psf	1,610.4596 psf	1,258.2289 psf	0 psf	0 psf	Gravel Borrow
Slice 29	17.50351 ft	195.80917 ft	-167.99769 psf	1,441.0569 psf	1,125.877 psf	0 psf	0 psf	Gravel Borrow
Slice 30	18.807976 ft	197.01045 ft	-161.36396 psf	1,300.0862 psf	1,015.7386 psf	0 psf	0 psf	Gravel Borrow
Slice 31	19.551966 ft	197.7408 ft	-160.21572 psf	1,228.0258 psf	959.43888 psf	0 psf	0 psf	Gravel Borrow
Slice 32	19.9975 ft	198.18414 ft	-162.27411 psf	1,132.0399 psf	884.44648 psf	0 psf	0 psf	Gravel Borrow
Slice 33	20.75 ft	198.97543 ft	-167.4718 psf	1,006.4714 psf	786.34161 psf	0 psf	0 psf	Gravel Borrow
Slice 34	22.364152 ft	200.74625 ft	-188.63507 psf	731.76451 psf	682.38145 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	23.614152 ft	202.19505 ft	-203.72234 psf	759.75519 psf	474.74773 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	24.25 ft	202.97438 ft	-211.31843 psf	733.50194 psf	458.34288 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	25.2 ft	204.20869 ft	-225.83795 psf	693.60486 psf	433.41242 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	25.95 ft	205.19907 ft	-239.25229 psf	662.78482 psf	414.15392 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 39	26.3 ft	205.68809 ft	-246.35413 psf	646.86418 psf	404.2056 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 40	27.286631 ft	207.13025 ft	-268.80823 psf	596.77214 psf	372.90462 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 41	28.954947 ft	209.78543 ft	-262.03638 psf	500.78421 psf	312.92471 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 42	30.918316 ft	213.32322 ft	-217.03131 psf	370.18618 psf	231.318 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 43	33.022443 ft	217.92455 ft	-189.37484 psf	367.90396 psf	229.89191 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 44	34.572311 ft	221.88658 ft	0 psf	161.5197 psf	100.92871 psf	0 psf	0 psf	Common Borrow

1B.3 Compound - Pseudo-Static FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
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Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:34:36 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.3 Compound - Pseudo-Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Reinforcements

Row 1 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (EQ)

Type: Geosynthetic

Interface Adhesion: 0 psf
Interface Shear Angle: 7.4 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes

Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 9.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Row 8 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.193

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)(EQ)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (19.6, 193.7) ft
Length: 19.6 ft
Orientation: 0 °
Slip Surface Intersection: (16.246848, 193.7) ft
Max. Pullout Force: 10,480 lbf
Available Length: 3.3531516 ft
Required Length: 3.3531516 ft
Pullout Force: 2,454.1915 lbf
Pullout Force per Length: 731.90591 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °

Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (19.6, 196.1) ft
Length: 19.6 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft

Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft

Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²
Region	ESU 2A Very Loose to Loose	18,17,14,19,84,20,9	115.05

6	Sand/Gravel (Apparent Cohesion)		ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region	Common Borrow	20,83,84	12.06

32			ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 4977 of 11466 converged

Current Slip Surface

Slip Surface: 2,992
Factor of Safety: 1.1
Volume: 1,169.6531 ft³
Weight: 124,808.04 lbf
Resisting Moment: 7,325,352 lbf·ft
Activating Moment: 6,497,179.6 lbf·ft
Resisting Force: 74,728.49 lbf
Activating Force: 66,278.191 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (46.999779, 223.24548) ft
Radius: 86.172023 ft
Center: (-26.222374, 268.67822) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.66352 ft	-181.70135 psf	259.35935 psf	162.06571 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-28.908333 ft	182.55933 ft	-179.7784 psf	398.30901 psf	248.89109 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 3	-26.125 ft	182.51749 ft	-178.18695 psf	591.91922 psf	369.87218 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 4	-23.341667 ft	182.56562 ft	-178.15181 psf	734.27525 psf	458.8261 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 5	-20.558333 ft	182.70386 ft	-177.22764 psf	837.55954 psf	523.36529 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel

								(Apparent Cohesion)
Slice 6	-17.775 ft	182.93265 ft	-176.31723 psf	910.47006 psf	568.92483 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-14.991667 ft	183.25271 ft	-176.12728 psf	959.29551 psf	599.43437 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 8	-12.333333 ft	183.64255 ft	-174.34767 psf	1,018.7807 psf	636.60487 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-9.8 ft	184.09537 ft	-176.51643 psf	1,088.0924 psf	679.91562 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-7.2666667 ft	184.62697 ft	-208.7245 psf	1,139.4288 psf	711.99411 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 11	-4.5 ft	185.30345 ft	-277.93069 psf	1,154.2898 psf	721.2803 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 12	-1.5 ft	186.14356 ft	-334.83655 psf	995.15809 psf	621.84379 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 13	0.49889422 ft	186.7556 ft	-361.11436 psf	2,920.3769 psf	1,824.8541 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 14	1.1763942 ft	186.97823 ft	-365.92602 psf	3,273.2131 psf	2,045.3305 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	2.76625 ft	187.54234 ft	-344.39989 psf	2,639.1842 psf	1,649.1453 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice	5.58875 ft	188.60723	-306.00015	2,394.3581	1,496.161	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

16		ft	psf	psf	psf			(Apparent Cohesion)
Slice 17	7.95 ft	189.57831 ft	-274.42646 psf	3,297.135 psf	2,060.2786 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	8.95 ft	190.01108 ft	-260.82303 psf	4,810.2884 psf	3,005.8018 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	11.048847 ft	191.01672 ft	-234.47322 psf	3,041.044 psf	1,900.2552 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 20	14.048847 ft	192.50284 ft	-185.52003 psf	2,863.6166 psf	2,237.3025 psf	0 psf	0 psf	Gravel Borrow
Slice 21	15.25 ft	193.14294 ft	-155.93155 psf	2,035.8237 psf	1,590.5598 psf	0 psf	0 psf	Gravel Borrow
Slice 22	16 ft	193.56125 ft	-143.41807 psf	1,811.6956 psf	1,415.4517 psf	0 psf	0 psf	Gravel Borrow
Slice 23	17.50351 ft	194.4333 ft	-118.8729 psf	1,530.5419 psf	1,195.7904 psf	0 psf	0 psf	Gravel Borrow
Slice 24	19.25351 ft	195.48813 ft	-101.97239 psf	1,388.4035 psf	1,084.7397 psf	0 psf	0 psf	Gravel Borrow
Slice 25	20.75 ft	196.43964 ft	-91.862423 psf	1,269.903 psf	992.15698 psf	0 psf	0 psf	Gravel Borrow
Slice 26	22.75 ft	197.79088 ft	-80.219783 psf	1,076.4082 psf	1,003.7669 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	24.25 ft	198.8351 ft	-75.466578 psf	1,038.14 psf	968.08125 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	25.2 ft	199.53637 ft	-73.462837 psf	1,013.4297 psf	945.0385 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	25.95 ft	200.09501 ft	-71.943607 psf	994.47707 psf	927.36487 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	26.3 ft	200.3637 ft	-71.688883 psf	985.07699 psf	918.59915 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	27.925 ft	201.66496 ft	-70.027784 psf	934.22181 psf	871.17593 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	30.575 ft	203.89728 ft	-71.817883 psf	847.52618 psf	790.33095 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	33.4 ft	206.49727 ft	-81.425728 psf	895.9252 psf	835.46376 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel

Slice 34	36.4 ft	209.52347 ft	-107.55454 psf	682.59375 psf	636.52897 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	38.65 ft	211.96937 ft	-147.20056 psf	534.07725 psf	498.03509 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	39.8 ft	213.30426 ft	-180.8029 psf	461.80001 psf	430.63547 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	41 ft	214.77892 ft	-225.42876 psf	395.03585 psf	368.37689 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	42.19125 ft	216.28758 ft	-286.19481 psf	333.90943 psf	311.37558 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	43.679617 ft	218.32143 ft	-384.87387 psf	240.42843 psf	224.20314 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	45.888257 ft	221.54493 ft	0 psf	106.48785 psf	83.197425 psf	0 psf	0 psf	Gravel Borrow

1B.4 Compound - Pseudo-Static FC Wall (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
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Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:35:22 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.4 Compound - Pseudo-Static FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Morgenstern-Price
Settings
    Side Function
        Interslice force function option: Half-Sine
    PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
    Critical Slip Surface Source from: (none)
    Unit Weight of Water: 62.4 pcf
Slip Surface
    Direction of movement: Right to Left
    Use Passive Mode: No
    Slip Surface Option: Entry and Exit
    Critical slip surfaces saved: 20
    Optimize Critical Slip Surface Location: No
    Tension Crack Option: (none)
Distribution
    F of S Calculation Option: Constant
Advanced
    Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Reinforcements

Row 1 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.4 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 9.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Row 8 (4 straps)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 10,480 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 10,480 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Seismic Coefficients

Horz Seismic Coef.: 0.193

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)(EQ)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (19.6, 193.7) ft
Length: 19.6 ft
Orientation: 0 °
Slip Surface Intersection: (16.246848, 193.7) ft
Max. Pullout Force: 10,480 lbf
Available Length: 3.3531516 ft
Required Length: 3.3531516 ft
Pullout Force: 2,454.1915 lbf
Pullout Force per Length: 731.90591 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3 (EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft

Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)(EQ)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (19.6, 196.1) ft
Length: 19.6 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y

Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft

Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	8,16,17,18	31.556 ft²

Region 6	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²

Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 7284 of 11466 converged

Current Slip Surface

Slip Surface: 2,992
Factor of Safety: 1.1
Volume: 1,169.6531 ft³
Weight: 124,808.04 lbf
Resisting Moment: 7,283,416.6 lbf·ft
Activating Moment: 6,497,179.6 lbf·ft
Resisting Force: 74,282.981 lbf
Activating Force: 66,318.601 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-32.349646, 182.72432) ft
Entry: (46.999779, 223.24548) ft
Radius: 86.172023 ft
Center: (-26.222374, 268.67822) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-31.324823 ft	182.66352 ft	-181.70135 psf	32.947971 psf	20.588177 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 2	-28.908333 ft	182.55933 ft	-179.7784 psf	156.3564 psf	97.702324 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 3	-26.125 ft	182.51749 ft	-178.18695 psf	358.02565 psf	223.71926 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 4	-23.341667 ft	182.56562 ft	-178.15181 psf	566.44517 psf	353.95423 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice	-20.558333	182.70386	-177.22764	770.61924	481.53635			ESU 2A Very Loose to Loose

5	ft	ft	psf	psf	psf	100 psf	0 psf	Sand/Gravel (Apparent Cohesion)
Slice 6	-17.775 ft	182.93265 ft	-176.31723 psf	956.22078 psf	597.51306 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 7	-14.991667 ft	183.25271 ft	-176.12728 psf	1,108.3344 psf	692.56421 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 8	-12.333333 ft	183.64255 ft	-174.34767 psf	1,242.0237 psf	776.10255 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 9	-9.8 ft	184.09537 ft	-176.51643 psf	1,354.0937 psf	846.13163 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 10	-7.2666667 ft	184.62697 ft	-208.7245 psf	1,418.5131 psf	886.38534 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 11	-4.5 ft	185.30345 ft	-277.93069 psf	1,427.3134 psf	891.88439 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 12	-1.5 ft	186.14356 ft	-334.83655 psf	1,223.7458 psf	764.68127 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 13	0.49889422 ft	186.7556 ft	-361.11436 psf	3,148.0959 psf	1,967.1486 psf	100 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel (Apparent Cohesion)
Slice 14	1.1763942 ft	186.97823 ft	-365.92602 psf	3,599.8728 psf	2,249.4502 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	2.76625 ft	187.54234 ft	-344.39989 psf	2,787.2829 psf	1,741.6877 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 2B Medium Dense

Slice 16	5.58875 ft	188.60723 ft	-306.00015 psf	2,451.2367 psf	1,531.7027 psf	200 psf	0 psf	Sand/Gravel (Apparent Cohesion)
Slice 17	7.95 ft	189.57831 ft	-274.42646 psf	3,262.2581 psf	2,038.4851 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	8.95 ft	190.01108 ft	-260.82303 psf	5,179.559 psf	3,236.5477 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	11.048847 ft	191.01672 ft	-234.47322 psf	2,917.5116 psf	1,823.0636 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 20	14.048847 ft	192.50284 ft	-185.52003 psf	2,728.6241 psf	2,131.8348 psf	0 psf	0 psf	Gravel Borrow
Slice 21	15.25 ft	193.14294 ft	-155.93155 psf	1,947.5448 psf	1,521.5888 psf	0 psf	0 psf	Gravel Borrow
Slice 22	16 ft	193.56125 ft	-143.41807 psf	1,678.6124 psf	1,311.4758 psf	0 psf	0 psf	Gravel Borrow
Slice 23	17.50351 ft	194.4333 ft	-118.8729 psf	1,358.911 psf	1,061.6976 psf	0 psf	0 psf	Gravel Borrow
Slice 24	19.25351 ft	195.48813 ft	-101.97239 psf	1,215.2532 psf	949.45986 psf	0 psf	0 psf	Gravel Borrow
Slice 25	20.75 ft	196.43964 ft	-91.862423 psf	1,101.3 psf	860.4299 psf	0 psf	0 psf	Gravel Borrow
Slice 26	22.75 ft	197.79088 ft	-80.219783 psf	914.9263 psf	853.18258 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 27	24.25 ft	198.8351 ft	-75.466578 psf	882.32657 psf	822.78284 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 28	25.2 ft	199.53637 ft	-73.462837 psf	864.13968 psf	805.82329 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 29	25.95 ft	200.09501 ft	-71.943607 psf	851.26163 psf	793.81431 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 30	26.3 ft	200.3637 ft	-71.688883 psf	845.17767 psf	788.14093 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 31	27.925 ft	201.66496 ft	-70.027784 psf	812.76208 psf	757.9129 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 32	30.575 ft	203.89728 ft	-71.817883 psf	763.07048 psf	711.57474 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	33.4 ft	206.49727 ft	-81.425728 psf	877.41276 psf	818.20063 psf	0 psf	0 psf	ESU 4B Dense to Very Dense

								Sand/Gravel
Slice 34	36.4 ft	209.52347 ft	-107.55454 psf	713.75052 psf	665.58313 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 35	38.65 ft	211.96937 ft	-147.20056 psf	593.47702 psf	553.42627 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 36	39.8 ft	213.30426 ft	-180.8029 psf	531.35474 psf	495.49631 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 37	41 ft	214.77892 ft	-225.42876 psf	473.35616 psf	441.41176 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 38	42.19125 ft	216.28758 ft	-286.19481 psf	418.22608 psf	390.00213 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 39	43.679617 ft	218.32143 ft	-384.87387 psf	316.90475 psf	295.51846 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 40	45.888257 ft	221.54493 ft	0 psf	158.2982 psf	123.67611 psf	0 psf	0 psf	Gravel Borrow

1B.5 Compound - Post-Seismic FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
Date: 01/17/2022
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Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:36:48 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.5 Compound - Post-Seismic FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Spencer
Settings
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1

F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °

Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (15.079752, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 4.9202484 ft
Required Length: 4.9202484 ft
Pullout Force: 2,676.0338 lbf
Pullout Force per Length: 543.88185 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes
Outside Point: (0, 205.7) ft

Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.823618, 196.1) ft
Max. Pullout Force: 7,860 lbf
Available Length: 2.1763818 ft
Required Length: 2.1763818 ft
Pullout Force: 1,235.7543 lbf
Pullout Force per Length: 567.80217 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft
Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft

Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²
Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²

Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²
Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²

Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 7204 of 11466 converged

Current Slip Surface

Slip Surface: 1,107
Factor of Safety: 1.4
Volume: 1,073.5733 ft³
Weight: 111,802.73 lbf
Resisting Moment: 4,386,087.4 lbf·ft
Activating Moment: 3,241,849 lbf·ft
Resisting Force: 59,552.604 lbf
Activating Force: 44,024.581 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-40.78762, 181.90624) ft
Entry: (34.999735, 223.15166) ft
Radius: 62.096408 ft
Center: (-24.243501, 241.75819) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-39.04381 ft	181.47809 ft	-184.62609 psf	123.81635 psf	77.36904 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	180.8223 ft	-184.06914 psf	288.25531 psf	180.12191 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.41291 ft	-182.77569 psf	376.72065 psf	235.40119 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-31.466667 ft	180.0945 ft	-181.51734 psf	441.19006 psf	275.68615 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-29.107143 ft	179.86411 ft	-179.81086 psf	550.81081 psf	344.1848 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.721429 ft	179.72272 ft	-178.81296 psf	698.81627 psf	436.66887 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice	-24.335714	179.67331	-179.75536	820.45877	512.67954			ESU 2A Very

7	ft	ft	psf	psf	psf	0 psf	0 psf	Loose to Loose Sand/Gravel
Slice 8	-21.95 ft	179.71563 ft	-179.27882 psf	919.12427 psf	574.33259 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-19.564286 ft	179.84989 ft	-177.12713 psf	997.49436 psf	623.30365 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-17.178571 ft	180.07667 ft	-181.32295 psf	1,057.7199 psf	660.93676 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-14.792857 ft	180.39702 ft	-186.651 psf	1,101.5452 psf	688.32181 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-12.339565 ft	180.82699 ft	-200.67145 psf	1,158.772 psf	724.08113 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-9.8186957 ft	181.37434 ft	-296.88615 psf	1,226.3801 psf	766.32737 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 14	-7.2791304 ft	182.0388 ft	-383.76897 psf	1,275.7966 psf	797.20619 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 15	-5.5625 ft	182.54017 ft	-404.88014 psf	1,374.8823 psf	859.12182 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-3.84375 ft	183.12395 ft	-383.82621 psf	1,213.807 psf	758.47081 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	-1.28125 ft	184.07979 ft	-351.82381 psf	1,073.5699 psf	670.84093 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	0.6775 ft	184.88675 ft	-329.17673 psf	2,896.2868 psf	1,809.8009 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	2.76625 ft	185.86561 ft	-306.5904 psf	2,665.497 psf	1,665.5874 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	5.58875 ft	187.32097 ft	-277.57173 psf	2,417.5455 psf	1,510.6501 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.67045 ft	-254.88611 psf	3,318.3387 psf	2,073.5281 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	8.95 ft	189.27817 ft	-245.58458 psf	4,210.4917 psf	2,631.0072 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	9.9765041 ft	189.95485 ft	-236.93585 psf	3,185.638 psf	1,990.6076 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	11.929512 ft	191.29995 ft	-220.10199 psf	2,968.5792 psf	1,854.9742 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice	13.143619	192.17917	-209.68292	2,922.1893	2,283.0645			

25	ft	ft	psf	psf	psf	0 psf	0 psf	Gravel Borrow
Slice 26	14.190611 ft	192.99631 ft	-199.12368 psf	2,648.2369 psf	2,069.0294 psf	0 psf	0 psf	Gravel Borrow
Slice 27	15.25 ft	193.84032 ft	-186.82298 psf	1,754.8457 psf	1,371.0358 psf	0 psf	0 psf	Gravel Borrow
Slice 28	16 ft	194.4719 ft	-180.08144 psf	1,524.7405 psf	1,191.2579 psf	0 psf	0 psf	Gravel Borrow
Slice 29	17.50351 ft	195.80917 ft	-167.99769 psf	1,352.2467 psf	1,056.4909 psf	0 psf	0 psf	Gravel Borrow
Slice 30	18.807976 ft	197.01045 ft	-161.36396 psf	1,204.7926 psf	941.28717 psf	0 psf	0 psf	Gravel Borrow
Slice 31	20.304466 ft	198.53209 ft	-165.59074 psf	1,047.5981 psf	818.47332 psf	0 psf	0 psf	Gravel Borrow
Slice 32	22.364152 ft	200.74625 ft	-188.63507 psf	728.83243 psf	679.64724 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	23.614152 ft	202.19505 ft	-203.72234 psf	724.21532 psf	452.53996 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	24.25 ft	202.97438 ft	-211.31843 psf	690.10922 psf	431.2281 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	25.2 ft	204.20869 ft	-225.83795 psf	638.33078 psf	398.87334 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	25.95 ft	205.19907 ft	-239.25229 psf	598.35775 psf	373.89542 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	26.3 ft	205.68809 ft	-246.35413 psf	578.38805 psf	361.41697 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	27.286631 ft	207.13025 ft	-268.80823 psf	517.78251 psf	323.54642 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 39	28.954947 ft	209.78543 ft	-262.03638 psf	408.32431 psf	255.14934 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 40	30.918316 ft	213.32322 ft	-217.03131 psf	272.75071 psf	170.43356 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 41	33.022443 ft	217.92455 ft	-189.37484 psf	241.49349 psf	150.90188 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 42	34.572311 ft	221.88658 ft	0 psf	77.921513 psf	48.690766 psf	0 psf	0 psf	Common Borrow

1B.6 Compound - Post-Seismic FC Wall (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 652
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Tool Version: 11.1.1.22085
File Name: Wall 05.85L-A - Sta 1+90 - (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-A\22-01-17\
Last Solved Date: 01/17/2022
Last Solved Time: 02:37:10 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.6 Compound - Post-Seismic FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Parent: 1. Steady State (Compound)
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from Parent Analysis: 1. Steady State (Compound) [(last)]
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 20
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 2A Very Loose to Loose Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °

ESU 2B Medium Dense Sand/Gravel (Residual Strength)

Material Model: Mohr-Coulomb
Unit Weight: 110 pcf
Effective Cohesion: 497 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °

Reinforcements

Row 1

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf

Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6

Type: Geosynthetic
Interface Adhesion: 0 psf

Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Row 8 (4 straps)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 7,860 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 7,860 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-45, 181.43065) ft
Left-Zone Right Coordinate: (0, 200) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15, 223) ft
Right-Zone Right Coordinate: (55, 223.299) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-100, 170.1) ft
Right Coordinate: (100, 223.6) ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1
Lock to Ground Surface: Yes
Outside Point: (0, 210.5) ft
Inside Point: (15.5, 210.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 8 (4 straps)
Lock to Ground Surface: No
Outside Point: (0, 193.7) ft
Inside Point: (20, 193.7) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (15.079752, 193.7) ft
Max. Pullout Force: 7,860 lbf
Available Length: 4.9202484 ft
Required Length: 4.9202484 ft
Pullout Force: 2,676.0338 lbf
Pullout Force per Length: 543.88185 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 3

Reinforcement: Row 6
Lock to Ground Surface: Yes
Outside Point: (0, 198.5) ft
Inside Point: (15.5, 198.5) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf

Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 2
Lock to Ground Surface: Yes
Outside Point: (0, 208.1) ft
Inside Point: (15.5, 208.1) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 5
Lock to Ground Surface: Yes
Outside Point: (0, 200.9) ft
Inside Point: (15.5, 200.9) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 4
Lock to Ground Surface: Yes
Outside Point: (0, 203.3) ft
Inside Point: (15.5, 203.3) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 3
Lock to Ground Surface: Yes

Outside Point: (0, 205.7) ft
Inside Point: (15.5, 205.7) ft
Length: 15.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 7 (4 straps)
Lock to Ground Surface: Yes
Outside Point: (0, 196.1) ft
Inside Point: (20, 196.1) ft
Length: 20 ft
Orientation: 0 °
Slip Surface Intersection: (17.823618, 196.1) ft
Max. Pullout Force: 7,860 lbf
Available Length: 2.1763818 ft
Required Length: 2.1763818 ft
Pullout Force: 1,235.7543 lbf
Pullout Force per Length: 567.80217 lbf/ft
Governing Component: Pullout Resistance

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	9 ft	224 ft
	26 ft	224 ft
	39.4 ft	224.2 ft
	40.2 ft	224.2 ft
	100 ft	224.6 ft

Geometry

Name: Default Geometry

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	100 ft	160 ft
Point 2	100 ft	185.5 ft
Point 3	0.9 ft	160 ft
Point 4	100 ft	211.1475 ft
Point 5	3.8 ft	183 ft
Point 6	-20.1275 ft	160 ft
Point 7	100 ft	219.64 ft
Point 8	42.5825 ft	219.8525 ft
Point 9	40.2 ft	223.2 ft
Point 10	100 ft	223.6 ft
Point 11	0 ft	211.7 ft
Point 12	0 ft	192 ft
Point 13	13 ft	192 ft
Point 14	24.5 ft	213.8 ft
Point 15	24.5 ft	192 ft
Point 16	24.5 ft	203 ft
Point 17	24.5 ft	205 ft
Point 18	41.8 ft	220.7 ft
Point 19	26.6 ft	215.4 ft
Point 20	37.9 ft	223.2 ft
Point 21	6.13959 ft	185.3 ft
Point 22	8.9 ft	192 ft
Point 23	-100 ft	160 ft
Point 24	-100 ft	170.1 ft
Point 25	-91.8 ft	174.4 ft
Point 26	-88.3 ft	176.5 ft
Point 27	-85.7 ft	177.8 ft
Point 28	-83.4 ft	178.4 ft
Point 29	-76 ft	178.9 ft
Point 30	-74 ft	179.7 ft
Point 31	-55.9 ft	180.2 ft
Point 32	-37.3 ft	182.3 ft
Point 33	-30.3 ft	182.9 ft
Point 34	-13.6 ft	190.2 ft
Point 35	7 ft	223 ft
Point 36	15 ft	223 ft
Point 37	15 ft	211.7 ft
Point 38	7 ft	211.7 ft
Point 39	-6 ft	195 ft
Point 40	-37.3275 ft	162.2725 ft
Point 41	-47.26 ft	160 ft
Point 42	-5.125 ft	182.98095 ft
Point 43	80.7025 ft	160 ft
Point 44	-100 ft	129.8675 ft

Point 45	100 ft	129.8675 ft
Point 46	-100 ft	147.8625 ft
Point 47	-27.95 ft	152.3875 ft
Point 48	-100 ft	133.97 ft
Point 49	16.5 ft	197.3 ft
Point 50	100 ft	209.9025 ft
Point 51	95.42762 ft	209.80965 ft
Point 52	3.915 ft	160.77581 ft
Point 53	17.7925 ft	187.09412 ft
Point 54	28.7 ft	129.8675 ft
Point 55	0 ft	198.7 ft
Point 56	47.15 ft	195.68393 ft
Point 57	42.67 ft	194.37311 ft
Point 58	0 ft	195 ft
Point 59	-32.3 ft	165.4 ft
Point 60	-16 ft	164.1 ft
Point 61	-100 ft	150.0525 ft
Point 62	15 ft	218.535 ft
Point 63	24 ft	223 ft
Point 64	7 ft	214.495 ft
Point 65	1.355 ft	211.7 ft
Point 66	25.9 ft	223 ft
Point 67	22 ft	192 ft
Point 68	15.0117 ft	208.01106 ft
Point 69	21.5 ft	192 ft
Point 70	15.5 ft	192 ft
Point 71	15.5 ft	211.7 ft
Point 72	15.5 ft	194.35 ft
Point 73	15.5 ft	197.3 ft
Point 74	15.5 ft	208.29 ft
Point 75	18.50702 ft	197.3 ft
Point 76	15.5 ft	196.43333 ft
Point 77	21.5 ft	211.7 ft
Point 78	20 ft	197.3 ft
Point 79	20 ft	192 ft
Point 80	21.5 ft	202 ft
Point 81	21.5 ft	200 ft
Point 82	21.5 ft	208.29 ft
Point 83	31.9 ft	223.1 ft
Point 84	31.9 ft	219.08 ft

Regions

	Material	Points	Area
Region 1	ESU 4B Dense to Very Dense Sand/Gravel	1,2,52,3,43	1,263.5 ft²
Region 2	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	52,2,50,51,56,57,53,5,60,6,47,3	2,656.9 ft²
Region 3	Gravel Borrow	9,18,8,7,10	214.55 ft²

Region 4	Gravel Borrow	38,65,11,55,68,74,71,37	127 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	8,16,17,18	31.556 ft²
Region 6	ESU 2A Very Loose to Loose Sand/Gravel	18,17,14,19,84,20,9	115.05 ft²
Region 7	Forward Compatible Wall	38,37,62,64	38.52 ft²
Region 8	Lightweight EPS	14,19,84,83,66,63,62,37,71,77	132.58 ft²
Region 9	ESU 2B Medium Dense Sand/Gravel	22,42,59,40,60,5,21,13	332.37 ft²
Region 10	ESU 4B Dense to Very Dense Sand/Gravel	44,54,45,1,43,3,47,48	4,704.7 ft²
Region 11	ESU 2B Medium Dense Sand/Gravel (Residual Strength)	41,46,48,47,6,60,40	992.46 ft²
Region 12	ESU 4B Dense to Very Dense Sand/Gravel	56,51,50,4,7,8,16,15,67,69,79,70,13,21,5,53,57	1,417.8 ft²
Region 13	ESU 2A Very Loose to Loose Sand/Gravel	34,33,32,31,30,29,28,27,26,25,24,23,40,59,42,22,12,58,39	1,656.2 ft²
Region 14	ESU 2A Very Loose to Loose Sand/Gravel	40,23,61,46,41	379.99 ft²
Region 15	Lightweight EPS	63,36,62	20.093 ft²
Region 16	Forward Compatible Wall	36,35,64,62	51.88 ft²
Region 17		64,65,38	7.8889 ft²
Region 18	ESU 4B Dense to Very Dense Sand/Gravel	15,16,81,69,67	28.5 ft²
Region 19	Gravel Borrow	72,76,22,13	11.692 ft²
Region 20	Gravel Borrow	70,72,13	2.9375 ft²
Region 21	Gravel Borrow	70,79,78,75,72	19.415 ft²
Region 22	Gravel Borrow	81,75,78,79,69	11.991 ft²
Region 23	Gravel Borrow	49,75,81,80	7.7095 ft²
Region 24	Gravel Borrow	49,76,72,75	4.002 ft²
Region 25	Gravel Borrow	73,76,49	0.43333 ft²
Region 26	Gravel Borrow	76,73,74,68,55,58,12,22	163.72 ft²
Region 27	ESU 2B Medium Dense Sand/Gravel	80,81,16,17	6 ft²
Region 28	Gravel Borrow	74,82,77	10.23 ft²
Region 29	Gravel Borrow	77,71,74	10.23 ft²

Region 30	ESU 2A Very Loose to Loose Sand/Gravel	77,82,80,17,14	27.75 ft²
Region 31	Gravel Borrow	73,49,80,82,74	54.19 ft²
Region 32	Common Borrow	20,83,84	12.06 ft²
Region 33		55,39,58	11.1 ft²

Slip Results

Slip Surfaces Analysed: 9050 of 11466 converged

Current Slip Surface

Slip Surface: 1,107
Factor of Safety: 1.4
Volume: 1,073.5733 ft³
Weight: 111,802.73 lbf
Resisting Moment: 4,383,546 lbf·ft
Activating Moment: 3,241,849 lbf·ft
Resisting Force: 59,476.883 lbf
Activating Force: 44,000.313 lbf
Slip Rank: 1 of 11,466 slip surfaces
Exit: (-40.78762, 181.90624) ft
Entry: (34.999735, 223.15166) ft
Radius: 62.096408 ft
Center: (-24.243501, 241.75819) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-39.04381 ft	181.47809 ft	-184.62609 psf	83.389882 psf	52.107782 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 2	-36.133333 ft	180.8223 ft	-184.06914 psf	219.41643 psf	137.1066 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 3	-33.8 ft	180.41291 ft	-182.77569 psf	315.86667 psf	197.3754 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 4	-31.466667 ft	180.0945 ft	-181.51734 psf	402.5666 psf	251.55153 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 5	-29.107143 ft	179.86411 ft	-179.81086 psf	534.78573 psf	334.17121 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 6	-26.721429 ft	179.72272 ft	-178.81296 psf	710.09312 psf	443.71543 psf	0 psf	0 psf	ESU 2A Very Loose to Loose

								Sand/Gravel
Slice 7	-24.335714 ft	179.67331 ft	-179.75536 psf	866.04829 psf	541.16703 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 8	-21.95 ft	179.71563 ft	-179.27882 psf	997.86932 psf	623.53796 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 9	-19.564286 ft	179.84989 ft	-177.12713 psf	1,102.3615 psf	688.83192 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 10	-17.178571 ft	180.07667 ft	-181.32295 psf	1,178.1422 psf	736.18494 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 11	-14.792857 ft	180.39702 ft	-186.651 psf	1,225.586 psf	765.83113 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 12	-12.339565 ft	180.82699 ft	-200.67145 psf	1,275.3252 psf	796.91164 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 13	-9.8186957 ft	181.37434 ft	-296.88615 psf	1,325.3269 psf	828.15618 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 14	-7.2791304 ft	182.0388 ft	-383.76897 psf	1,348.4002 psf	842.57397 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 15	-5.5625 ft	182.54017 ft	-404.88014 psf	1,458.6085 psf	911.43975 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	-3.84375 ft	183.12395 ft	-383.82621 psf	1,251.5605 psf	782.06177 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	-1.28125 ft	184.07979 ft	-351.82381 psf	1,074.8732 psf	671.6553 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	0.6775 ft	184.88675 ft	-329.17673 psf	2,892.9136 psf	1,807.6931 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	2.76625 ft	185.86561 ft	-306.5904 psf	2,613.821 psf	1,633.2966 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	5.58875 ft	187.32097 ft	-277.57173 psf	2,330.1541 psf	1,456.0419 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	7.95 ft	188.67045 ft	-254.88611 psf	3,206.8551 psf	2,003.8654 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	8.95 ft	189.27817 ft	-245.58458 psf	4,229.6732 psf	2,642.9932 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	9.9765041 ft	189.95485 ft	-236.93585 psf	3,066.5375 psf	1,916.1853 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice	11.929512	191.29995	-220.10199	2,856.7275	1,785.0815	0 psf	0 psf	ESU 2B Medium Dense

24	ft	ft	psf	psf	psf			Sand/Gravel
Slice 25	13.143619 ft	192.17917 ft	-209.68292 psf	2,825.5047 psf	2,207.5262 psf	0 psf	0 psf	Gravel Borrow
Slice 26	14.190611 ft	192.99631 ft	-199.12368 psf	2,551.6239 psf	1,993.547 psf	0 psf	0 psf	Gravel Borrow
Slice 27	15.25 ft	193.84032 ft	-186.82298 psf	1,653.6156 psf	1,291.9461 psf	0 psf	0 psf	Gravel Borrow
Slice 28	16 ft	194.4719 ft	-180.08144 psf	1,432.9214 psf	1,119.5209 psf	0 psf	0 psf	Gravel Borrow
Slice 29	17.50351 ft	195.80917 ft	-167.99769 psf	1,271.7022 psf	993.56267 psf	0 psf	0 psf	Gravel Borrow
Slice 30	18.807976 ft	197.01045 ft	-161.36396 psf	1,137.0924 psf	888.39391 psf	0 psf	0 psf	Gravel Borrow
Slice 31	20.304466 ft	198.53209 ft	-165.59074 psf	994.48442 psf	776.97638 psf	0 psf	0 psf	Gravel Borrow
Slice 32	22.364152 ft	200.74625 ft	-188.63507 psf	683.05666 psf	636.96064 psf	0 psf	0 psf	ESU 4B Dense to Very Dense Sand/Gravel
Slice 33	23.614152 ft	202.19505 ft	-203.72234 psf	706.74256 psf	441.62177 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	24.25 ft	202.97438 ft	-211.31843 psf	680.76759 psf	425.3908 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	25.2 ft	204.20869 ft	-225.83795 psf	641.20215 psf	400.66757 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	25.95 ft	205.19907 ft	-239.25229 psf	610.65085 psf	381.577 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	26.3 ft	205.68809 ft	-246.35413 psf	594.92586 psf	371.75094 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	27.286631 ft	207.13025 ft	-268.80823 psf	545.16573 psf	340.65735 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 39	28.954947 ft	209.78543 ft	-262.03638 psf	449.52517 psf	280.8945 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 40	30.918316 ft	213.32322 ft	-217.03131 psf	319.16457 psf	199.43616 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 41	33.022443 ft	217.92455 ft	-189.37484 psf	318.96888 psf	199.31388 psf	0 psf	0 psf	ESU 2A Very Loose to Loose Sand/Gravel
Slice 42	34.572311 ft	221.88658 ft	0 psf	113.12324 psf	70.687249 psf	0 psf	0 psf	Common Borrow

1A.1 Compound - Static (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 318
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Tool Version: 11.1.1.22085
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/13/2022
Last Solved Time: 03:59:52 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.1 Compound - Static (Spencer)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
- Maximum Number of Iterations: 100
- Tolerable difference in F of S: 0.001

Solution Settings
- Search Method: Root Finder
- Tolerable difference between starting and converged F of S: 3
- Maximum iterations to calculate converged lambda: 20
- Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
- Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Row 1 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 8 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 9+ (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 2.7 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-35.900009, 192.42444) ft
Left-Zone Right Coordinate: (-0.9, 206) ft
Left-Zone Increment: 25

Right Type: Range
Right-Zone Left Coordinate: (15.000006, 226.34416) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft

Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft
Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 196.8) ft
Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (10.34791, 196.8) ft
Max. Pullout Force: 3,930 lbf
Available Length: 5.2520903 ft
Required Length: 5.2520903 ft
Pullout Force: 1,724.5562 lbf

Pullout Force per Length: 328.35616 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (14.253335, 199.2) ft
Max. Pullout Force: 3,930 lbf
Available Length: 1.3466647 ft
Required Length: 1.3466647 ft
Pullout Force: 431.2803 lbf
Pullout Force per Length: 320.25813 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	43 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft

Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 7	Gravel Borrow	32,35,38,36,37	26.85 ft²
Region 8	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	12,39,40,41,36,38,13	241.79 ft²
Region 9	Common Borrow	48,47,49,50	35.36 ft²
Region 10	Common Borrow	39,56,51,36,41,40	75.79 ft²
Region 11		46,54,49,42,52	58.52 ft²
Region 12		46,45,53,54	12 ft²
Region 13	Common Borrow	50,43,48	5.382 ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15		50,49,54,53	65.44 ft²
Region 16	Common Borrow	44,42,49,47,33,51,56,55	171.02 ft²

Region 17	Common Borrow	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 14669 of 16926 converged

Current Slip Surface

Slip Surface: 2,917
Factor of Safety: 1.4
Volume: 964.30153 ft³
Weight: 119,623.77 lbf
Resisting Moment: 3,841,902 lbf·ft
Activating Moment: 2,844,209.1 lbf·ft
Resisting Force: 65,066.742 lbf
Activating Force: 48,165.335 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-29.191505, 193.28886) ft
Entry: (35.110492, 233.5) ft
Radius: 48.823686 ft
Center: (-13.346822, 239.47001) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-27.993629 ft	192.91202 ft	-516.16509 psf	130.71595 psf	88.169023 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 2	-25.597876 ft	192.22456 ft	-439.10696 psf	326.08943 psf	219.9501 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 3	-23.575 ft	191.73716 ft	-379.8495 psf	487.19333 psf	328.61605 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-21.925 ft	191.41312 ft	-336.10212 psf	639.08296 psf	431.0669 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-19.7 ft	191.08204 ft	-283.71696 psf	762.05705 psf	514.01397 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-17.05 ft	190.80311 ft	-228.5258 psf	847.19412 psf	571.43965 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-14.55 ft	190.67717 ft	-185.02014 psf	895.81521 psf	604.23499 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-12.05 ft	190.67957 ft	-149.52288 psf	918.26194 psf	619.3755 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 9	-9.8166667 ft	190.7841 ft	-124.20051 psf	1,014.0565 psf	683.98973 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 10	-7.85 ft	190.96684 ft	-107.56117 psf	1,073.0544 psf	723.78431 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-5.8833333 ft	191.23042 ft	-95.966132 psf	1,115.1991 psf	752.21127 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-4.5 ft	191.45626 ft	-90.333895 psf	1,210.6808 psf	816.6145 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-2.5 ft	191.89475 ft	-88.611953 psf	988.18274 psf	666.53768 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	0.3 ft	192.609 ft	-92.265808 psf	3,363.9375 psf	2,269.0045 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	2.65 ft	193.35741 ft	-104.62665 psf	3,171.8341 psf	2,139.4291 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	4.95 ft	194.22137 ft	-124.92864 psf	3,042.1261 psf	2,051.94 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	6.9397335 ft	195.07006 ft	-148.81188 psf	2,938.9097 psf	1,982.3196 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	8.6192006 ft	195.87687 ft	-174.6153 psf	2,833.5592 psf	1,911.2598 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	10.579467 ft	196.93024 ft	-211.70084 psf	2,680.2437 psf	2,094.0359 psf	0 psf	0 psf	Gravel Borrow
Slice 20	12.9 ft	198.32599 ft	-267.76075 psf	2,464.3368 psf	1,925.3509 psf	0 psf	0 psf	Gravel Borrow
Slice 21	14.85 ft	199.62221 ft	-324.821 psf	2,304.7248 psf	1,800.6483 psf	0 psf	0 psf	Gravel Borrow
Slice 22	16.3825 ft	200.75378 ft	-376.70807 psf	2,157.4103 psf	1,685.5536 psf	0 psf	0 psf	Gravel Borrow
Slice 23	18.3225 ft	202.34197 ft	-446.64663 psf	1,915.9039 psf	1,292.2935 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 24	20.6375 ft	204.45264 ft	-539.14455 psf	1,716.9313 psf	1,158.0848 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	22.9525 ft	206.86463 ft	-650.44462 psf	1,504.2786 psf	1,014.6488 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 26	25.305 ft	209.70505 ft	-779.89613 psf	1,271.9474 psf	857.93936 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 27	27.6375 ft	213.01935 ft	-931.69096 psf	1,023.7669 psf	690.53948 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 28	29.095109 ft	215.34502 ft	-1,042.4314 psf	864.18986 psf	582.90342 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 29	29.457609 ft	215.98544 ft	-1,073.8429 psf	768.11291 psf	667.71037 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 30	29.51 ft	216.08102 ft	-1,078.5718 psf	761.62025 psf	662.06638 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 31	30.51 ft	218.13436 ft	-1,182.9845 psf	612.46929 psf	532.41143 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 32	31.865 ft	221.06604 ft	-1,333.7853 psf	426.82944 psf	371.03717 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 33	32.811756 ft	223.66134 ft	-1,472.4813 psf	289.67872 psf	251.81387 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 34	33.754961 ft	226.69236 ft	-1,637.9556 psf	183.77908 psf	114.83791 psf	0 psf	0 psf	Common Borrow
Slice 35	34.613451 ft	230.76238 ft	-1,870.3884 psf	53.915981 psf	33.690444 psf	0 psf	0 psf	Common Borrow

1A.2 Compound - Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 318
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Tool Version: 11.1.1.22085
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/13/2022
Last Solved Time: 04:00:28 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.2 Compound - Static (M-P)

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Row 1 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 8 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 9+ (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 2.7 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-35.900009, 192.42444) ft
Left-Zone Right Coordinate: (-0.9, 206) ft

Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15.000006, 226.34416) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 30
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft

Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft
Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 196.8) ft
Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (8.7606853, 196.8) ft
Max. Pullout Force: 3,930 lbf
Available Length: 6.8393147 ft
Required Length: 6.8393147 ft
Pullout Force: 2,183.2842 lbf

Pullout Force per Length: 319.22558 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (12.7803, 199.2) ft
Max. Pullout Force: 3,930 lbf
Available Length: 2.8197002 ft
Required Length: 2.8197002 ft
Pullout Force: 883.16088 lbf
Pullout Force per Length: 313.21092 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	43 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft

Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 7	Gravel Borrow	32,35,38,36,37	26.85 ft²
Region 8	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	12,39,40,41,36,38,13	241.79 ft²
Region 9	Common Borrow	48,47,49,50	35.36 ft²
Region 10	Common Borrow	39,56,51,36,41,40	75.79 ft²
Region 11		46,54,49,42,52	58.52 ft²
Region 12		46,45,53,54	12 ft²
Region 13	Common Borrow	50,43,48	5.382 ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15		50,49,54,53	65.44 ft²
Region 16	Common Borrow	44,42,49,47,33,51,56,55	171.02 ft²

Region 17	Common Borrow	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 16544 of 16926 converged

Current Slip Surface

Slip Surface: 2,265
Factor of Safety: 1.4
Volume: 928.50885 ft³
Weight: 115,303.02 lbf
Resisting Moment: 3,899,195.6 lbf·ft
Activating Moment: 2,882,123.5 lbf·ft
Resisting Force: 62,661.305 lbf
Activating Force: 46,328.074 lbf
Slip Rank: 1 of 16,926 slip surfaces
Exit: (-30.881499, 193.17912) ft
Entry: (35.110492, 233.5) ft
Radius: 51.132236 ft
Center: (-15.328929, 241.8887) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-29.801249 ft	192.86025 ft	-538.70937 psf	56.321042 psf	37.989022 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 2	-27.640749 ft	192.27332 ft	-471.2788 psf	171.6749 psf	115.79618 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 3	-25.48025 ft	191.78639 ft	-410.08817 psf	285.30554 psf	192.44102 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-23.575 ft	191.43269 ft	-360.85056 psf	415.10506 psf	279.9919 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-21.925 ft	191.19052 ft	-322.21229 psf	561.412 psf	378.67717 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-19.7 ft	190.96302 ft	-276.2903 psf	719.55436 psf	485.34554 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-17.05 ft	190.80075 ft	-228.37841 psf	863.19223 psf	582.23051 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-14.55 ft	190.77769 ft	-191.29237 psf	959.35748 psf	647.09479 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 9	-12.05 ft	190.87708 ft	-161.84772 psf	1,010.2664 psf	681.43331 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 10	-9.8166667 ft	191.06408 ft	-141.6716 psf	1,142.9419 psf	770.92407 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-7.85 ft	191.31615 ft	-129.35837 psf	1,201.7526 psf	810.59239 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-5.8833333 ft	191.64644 ft	-121.926 psf	1,229.1342 psf	829.06148 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-4.5 ft	191.91799 ft	-119.146 psf	1,419.9113 psf	957.74224 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-2.5 ft	192.4196 ft	-121.36291 psf	1,049.4292 psf	707.84893 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	0.3 ft	193.21989 ft	-130.38527 psf	3,374.9653 psf	2,276.4429 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	2.65 ft	194.03732 ft	-147.05359 psf	3,111.5234 psf	2,098.749 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	4.95 ft	194.96642 ft	-171.41978 psf	2,908.2294 psf	1,961.6255 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	6.9632694 ft	195.88171 ft	-199.11505 psf	2,756.3233 psf	1,859.1635 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	8.7949041 ft	196.81832 ft	-230.79406 psf	2,600.0515 psf	2,031.3829 psf	0 psf	0 psf	Gravel Borrow
Slice 20	10.731635 ft	197.91046 ft	-270.64333 psf	2,351.7228 psf	1,837.3672 psf	0 psf	0 psf	Gravel Borrow
Slice 21	12.9 ft	199.2793 ft	-327.24758 psf	2,146.5509 psf	1,677.0693 psf	0 psf	0 psf	Gravel Borrow
Slice 22	14.85 ft	200.6228 ft	-387.25821 psf	1,960.3311 psf	1,531.5785 psf	0 psf	0 psf	Gravel Borrow
Slice 23	16.3825 ft	201.79013 ft	-441.37623 psf	1,831.3356 psf	1,430.7962 psf	0 psf	0 psf	Gravel Borrow
Slice 24	18.3225 ft	203.42155 ft	-514.01285 psf	1,625.0919 psf	1,096.1383 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 25	20.6375 ft	205.58076 ft	-609.53921 psf	1,476.4044 psf	995.84734 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 26	22.9525 ft	208.03631 ft	-723.55768 psf	1,330.2509 psf	897.26559 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 27	25.305 ft	210.91284 ft	-855.26237 psf	1,177.9053 psf	794.50715 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice		213.84623	-988.97439	1,034.57	697.8263			ESU 2B Medium

28	27.39643 ft	ft	psf	psf	psf	0 psf	0 psf	Dense Sand/Gravel
Slice 29	28.53393 ft	215.61448 ft	-1,072.4821 psf	862.9674 psf	750.16612 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 30	29.0875 ft	216.56503 ft	-1,118.7396 psf	812.85067 psf	706.60031 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 31	29.45 ft	217.20384 ft	-1,150.0509 psf	779.7648 psf	677.8392 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 32	29.51 ft	217.31279 ft	-1,155.4339 psf	773.90486 psf	672.74523 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 33	30.51 ft	219.34394 ft	-1,258.4626 psf	644.46469 psf	560.22461 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 34	31.865 ft	222.23324 ft	-1,406.6186 psf	474.83345 psf	412.76642 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 35	32.583646 ft	224.06001 ft	-1,503.0809 psf	374.38743 psf	325.45003 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 36	33.393451 ft	226.44996 ft	-1,631.8989 psf	311.68882 psf	194.76479 psf	0 psf	0 psf	Common Borrow
Slice 37	34.48005 ft	230.69476 ft	-1,869.5158 psf	104.33588 psf	65.196295 psf	0 psf	0 psf	Common Borrow

1A.3 Compound - Pseudo-Static (Spencer)

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File Information

File Version: 11.01
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Last Edited By: Yi Tyan Tsai
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Last Solved Date: 01/19/2022
Last Solved Time: 02:28:57 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.3 Compound - Pseudo-Static (Spencer)

Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30

Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Row 1 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed

Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.9 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 8 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 9+ (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-25, 193.56104) ft
Left-Zone Right Coordinate: (-0.9, 206) ft
Left-Zone Increment: 20

Right Type: Range
Right-Zone Left Coordinate: (21.860569, 229.72989) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.208

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft

Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (2.6901579, 204) ft
Max. Pullout Force: 5,240 lbf
Available Length: 12.909842 ft
Required Length: 12.909842 ft
Pullout Force: 4,613.2725 lbf
Pullout Force per Length: 357.34539 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (6.3238779, 206.4) ft
Max. Pullout Force: 5,240 lbf
Available Length: 9.2761221 ft
Required Length: 9.2761221 ft
Pullout Force: 3,523.3844 lbf
Pullout Force per Length: 379.83376 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (9.7925061, 208.8) ft
Max. Pullout Force: 5,240 lbf
Available Length: 5.8074939 ft
Required Length: 5.8074939 ft
Pullout Force: 2,390.913 lbf
Pullout Force per Length: 411.69444 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft
Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (13.115125, 211.2) ft
Max. Pullout Force: 5,240 lbf
Available Length: 2.4848745 ft
Required Length: 2.4848745 ft
Pullout Force: 1,049.766 lbf
Pullout Force per Length: 422.4624 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No
Outside Point: (-0.9, 196.8) ft

Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	43 ft	234.5 ft

	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft

Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft
Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 7	Gravel Borrow	32,35,38,36,37	26.85 ft²
Region 8	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	12,39,40,41,36,38,13	241.79 ft²
Region 9	Common Borrow (Apparent Cohesion)	48,47,49,50	35.36 ft²
Region 10	Common Borrow (Apparent Cohesion)	39,56,51,36,41,40	75.79 ft²
Region 11		46,54,49,42,52	58.52 ft²
Region 12		46,45,53,54	12 ft²
Region	Common Borrow (Apparent Cohesion)	50,43,48	5.382

13			ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15		50,49,54,53	65.44 ft²
Region 16	Common Borrow (Apparent Cohesion)	44,42,49,47,33,51,56,55	171.02 ft²
Region 17	Common Borrow (Apparent Cohesion)	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 6454 of 9261 converged

Current Slip Surface

Slip Surface: 6,366
Factor of Safety: 1.1
Volume: 451.08584 ft³
Weight: 56,233.146 lbf
Resisting Moment: 7,075,518.1 lbf·ft
Activating Moment: 6,661,339.1 lbf·ft
Resisting Force: 28,417.582 lbf
Activating Force: 26,776.632 lbf
Slip Rank: 1 of 9,261 slip surfaces
Exit: (-0.9, 201.73514) ft
Entry: (38.540419, 233.5) ft
Radius: 201.32979 ft
Center: (-106.4613, 373.17171) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-0.3 ft	202.1075 ft	-693.73979 psf	2,943.0247 psf	2,299.3429 psf	0 psf	0 psf	Gravel Borrow
Slice 2	0.9 ft	202.85808 ft	-723.04082 psf	2,848.9888 psf	2,225.874 psf	0 psf	0 psf	Gravel Borrow
Slice 3	2.2666667 ft	203.72826 ft	-757.36922 psf	2,426.5787 psf	1,895.851 psf	0 psf	0 psf	Gravel Borrow
Slice 4	3.8 ft	204.72204 ft	-796.97537 psf	1,625.1968 psf	1,269.7429 psf	0 psf	0 psf	Gravel Borrow
Slice 5	5.3333333 ft	205.73577 ft	-837.82579 psf	1,577.5718 psf	1,232.5342 psf	0 psf	0 psf	Gravel Borrow
Slice 6	6.8 ft	206.72398 ft	-878.05855 psf	1,575.8907 psf	1,231.2207 psf	0 psf	0 psf	Gravel Borrow
Slice 7	8.2 ft	207.68532 ft	-917.58815 psf	1,236.1727 psf	965.80399 psf	0 psf	0 psf	Gravel Borrow
Slice 8	9.6 ft	208.66419 ft	-958.21176 psf	1,196.5468 psf	934.84483 psf	0 psf	0 psf	Gravel Borrow

Slice 9	11 ft	209.6609 ft	-999.94902 psf	1,010.4433 psf	789.44479 psf	0 psf	0 psf	Gravel Borrow
Slice 10	12.3 ft	210.60207 ft	-1,041.119 psf	982.78465 psf	767.83552 psf	0 psf	0 psf	Gravel Borrow
Slice 11	13.5 ft	211.48555 ft	-1,081.5872 psf	949.7675 psf	742.03969 psf	0 psf	0 psf	Gravel Borrow
Slice 12	14.85 ft	212.49698 ft	-1,128.2065 psf	858.87059 psf	671.02325 psf	0 psf	0 psf	Gravel Borrow
Slice 13	16.3825 ft	213.66588 ft	-1,182.4229 psf	814.49163 psf	636.3506 psf	0 psf	0 psf	Gravel Borrow
Slice 14	17.8595 ft	214.81375 ft	-1,232.7275 psf	739.53991 psf	462.11582 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 15	19.2485 ft	215.91415 ft	-1,277.8677 psf	705.76374 psf	441.01013 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 16	20.6375 ft	217.03466 ft	-1,324.2629 psf	671.5971 psf	419.66045 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 17	22.0265 ft	218.17572 ft	-1,371.9402 psf	637.05382 psf	398.07541 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 18	23.4155 ft	219.33779 ft	-1,420.9284 psf	602.14781 psf	376.26371 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 19	24.693125 ft	220.42482 ft	-1,463.2426 psf	569.77766 psf	356.0366 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 20	25.859375 ft	221.43402 ft	-1,498.7078 psf	539.94007 psf	337.392 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 21	27.025625 ft	222.45901 ft	-1,535.1579 psf	509.87418 psf	318.60475 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 22	28.191875 ft	223.5001 ft	-1,572.613 psf	479.5884 psf	299.68009 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 23	29.1375 ft	224.35501 ft	-1,603.6549 psf	454.9442 psf	284.28069 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 24	29.51 ft	224.69447 ft	-1,616.0509 psf	444.96775 psf	278.04671 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 25	30.015 ft	225.16005 ft	-1,633.1275 psf	419.1682 psf	261.92536 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 26	31.005 ft	226.07908 ft	-1,666.9953 psf	369.03037 psf	230.59577 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 27	31.679841 ft	226.71131 ft	-1,690.4416 psf	335.13901 psf	209.4181 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice	32.044841	227.05645	-1,703.3219	316.84293	197.98543			Common Borrow

28	ft	ft	psf	psf	psf	50 psf	0 psf	(Apparent Cohesion)
Slice 29	32.861042 ft	227.8369 ft	-1,731.8003 psf	275.99712 psf	172.46214 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 30	34.123126 ft	229.05743 ft	-1,776.2998 psf	213.53162 psf	133.42937 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 31	35.385209 ft	230.29952 ft	-1,822.1457 psf	151.68708 psf	94.784606 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 32	36.647293 ft	231.56376 ft	-1,869.3733 psf	90.466884 psf	56.529983 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 33	37.909377 ft	232.85075 ft	-1,918.02 psf	29.873937 psf	18.667308 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)

1A.4 Compound - Pseudo-Static (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Yi Tyan Tsai
Revision Number: 321
Date: 01/19/2022
Time: 02:28:08 PM
Tool Version: 11.1.1.22085
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/19/2022
Last Solved Time: 02:28:24 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1A.4 Compound - Pseudo-Static (M-P)

Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure

Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Row 1 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.9 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 8 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 9+ (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-25, 193.56104) ft
Left-Zone Right Coordinate: (-0.9, 206) ft

Left-Zone Increment: 20
Right Type: Range
Right-Zone Left Coordinate: (21.860569, 229.72989) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 20
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.208

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (2.6901579, 204) ft
Max. Pullout Force: 5,240 lbf
Available Length: 12.909842 ft
Required Length: 12.909842 ft
Pullout Force: 4,613.2725 lbf
Pullout Force per Length: 357.34539 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (6.3238779, 206.4) ft
Max. Pullout Force: 5,240 lbf
Available Length: 9.2761221 ft
Required Length: 9.2761221 ft
Pullout Force: 3,523.3844 lbf
Pullout Force per Length: 379.83376 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (9.7925061, 208.8) ft
Max. Pullout Force: 5,240 lbf
Available Length: 5.8074939 ft
Required Length: 5.8074939 ft
Pullout Force: 2,390.913 lbf
Pullout Force per Length: 411.69444 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft
Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (13.115125, 211.2) ft
Max. Pullout Force: 5,240 lbf
Available Length: 2.4848745 ft
Required Length: 2.4848745 ft
Pullout Force: 1,049.766 lbf
Pullout Force per Length: 422.4624 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No

Outside Point: (-0.9, 196.8) ft
Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y

	43 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D

Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft

Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft
Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 7	Gravel Borrow	32,35,38,36,37	26.85 ft²
Region 8	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	12,39,40,41,36,38,13	241.79 ft²
Region 9	Common Borrow (Apparent Cohesion)	48,47,49,50	35.36 ft²
Region 10	Common Borrow (Apparent Cohesion)	39,56,51,36,41,40	75.79 ft²
Region 11		46,54,49,42,52	58.52 ft²
Region 12		46,45,53,54	12 ft²

Region 13	Common Borrow (Apparent Cohesion)	50,43,48	5.382 ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15		50,49,54,53	65.44 ft²
Region 16	Common Borrow (Apparent Cohesion)	44,42,49,47,33,51,56,55	171.02 ft²
Region 17	Common Borrow (Apparent Cohesion)	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 8969 of 9261 converged

Current Slip Surface

Slip Surface: 6,366
Factor of Safety: 1.1
Volume: 451.08584 ft³
Weight: 56,233.146 lbf
Resisting Moment: 7,126,191.7 lbf·ft
Activating Moment: 6,661,339.1 lbf·ft
Resisting Force: 28,638.037 lbf
Activating Force: 26,771.671 lbf
Slip Rank: 1 of 9,261 slip surfaces
Exit: (-0.9, 201.73514) ft
Entry: (38.540419, 233.5) ft
Radius: 201.32979 ft
Center: (-106.4613, 373.17171) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-0.3 ft	202.1075 ft	-693.73979 psf	1,722.3906 psf	1,345.6791 psf	0 psf	0 psf	Gravel Borrow
Slice 2	0.9 ft	202.85808 ft	-723.04082 psf	1,998.3832 psf	1,561.3081 psf	0 psf	0 psf	Gravel Borrow
Slice 3	2.2666667 ft	203.72826 ft	-757.36922 psf	2,189.4942 psf	1,710.6203 psf	0 psf	0 psf	Gravel Borrow
Slice 4	3.8 ft	204.72204 ft	-796.97537 psf	2,021.0539 psf	1,579.0204 psf	0 psf	0 psf	Gravel Borrow
Slice 5	5.3333333 ft	205.73577 ft	-837.82579 psf	2,023.8012 psf	1,581.1668 psf	0 psf	0 psf	Gravel Borrow
Slice 6	6.8 ft	206.72398 ft	-878.05855 psf	2,043.5056 psf	1,596.5615 psf	0 psf	0 psf	Gravel Borrow
Slice 7	8.2 ft	207.68532 ft	-917.58815 psf	1,721.5867 psf	1,345.0509 psf	0 psf	0 psf	Gravel Borrow
Slice		208.66419	-958.21176	1,614.95	1,261.7372			

8	9.6 ft	ft	psf	psf	psf	0 psf	0 psf	Gravel Borrow
Slice 9	11 ft	209.6609 ft	-999.94902 psf	1,328.855 psf	1,038.2153 psf	0 psf	0 psf	Gravel Borrow
Slice 10	12.3 ft	210.60207 ft	-1,041.119 psf	1,214.8362 psf	949.13404 psf	0 psf	0 psf	Gravel Borrow
Slice 11	13.5 ft	211.48555 ft	-1,081.5872 psf	1,107.3821 psf	865.18169 psf	0 psf	0 psf	Gravel Borrow
Slice 12	14.85 ft	212.49698 ft	-1,128.2065 psf	922.67976 psf	720.87644 psf	0 psf	0 psf	Gravel Borrow
Slice 13	16.3825 ft	213.66588 ft	-1,182.4229 psf	802.85189 psf	627.25664 psf	0 psf	0 psf	Gravel Borrow
Slice 14	17.8595 ft	214.81375 ft	-1,232.7275 psf	663.46287 psf	414.57761 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 15	19.2485 ft	215.91415 ft	-1,277.8677 psf	594.29056 psf	371.35396 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 16	20.6375 ft	217.03466 ft	-1,324.2629 psf	537.87316 psf	336.10045 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 17	22.0265 ft	218.17572 ft	-1,371.9402 psf	492.90721 psf	308.00261 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 18	23.4155 ft	219.33779 ft	-1,420.9284 psf	458.05499 psf	286.22453 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 19	24.693125 ft	220.42482 ft	-1,463.2426 psf	433.7466 psf	271.03496 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 20	25.859375 ft	221.43402 ft	-1,498.7078 psf	417.31609 psf	260.76804 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 21	27.025625 ft	222.45901 ft	-1,535.1579 psf	405.60365 psf	253.44929 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 22	28.191875 ft	223.5001 ft	-1,572.613 psf	397.93852 psf	248.65958 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 23	29.1375 ft	224.35501 ft	-1,603.6549 psf	394.20709 psf	246.32793 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 24	29.51 ft	224.69447 ft	-1,616.0509 psf	393.01522 psf	245.58316 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 25	30.015 ft	225.16005 ft	-1,633.1275 psf	378.85018 psf	236.73186 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 26	31.005 ft	226.07908 ft	-1,666.9953 psf	350.35448 psf	218.92578 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 27	31.679841 ft	226.71131 ft	-1,690.4416 psf	329.95642 psf	206.17965 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)

Slice 28	32.044841 ft	227.05645 ft	-1,703.3219 psf	318.30498 psf	198.89902 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 29	32.861042 ft	227.8369 ft	-1,731.8003 psf	290.11512 psf	181.28405 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 30	34.123126 ft	229.05743 ft	-1,776.2998 psf	240.9104 psf	150.53752 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 31	35.385209 ft	230.29952 ft	-1,822.1457 psf	181.76329 psf	113.57831 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 32	36.647293 ft	231.56376 ft	-1,869.3733 psf	109.52858 psf	68.441053 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)
Slice 33	37.909377 ft	232.85075 ft	-1,918.02 psf	20.619251 psf	12.884338 psf	50 psf	0 psf	Common Borrow (Apparent Cohesion)

1B.1 Compound - Static FC Wall (Spencer)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Bo Zhang
Revision Number: 314
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Time: 10:44:22 AM
Tool Version: 11.1.1.22700
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/12/2022
Last Solved Time: 10:46:40 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.1 Compound - Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Row 1 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 8 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 9+ (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 2.7 °
Surface Area Factor: 2

Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 191.94781) ft
Left-Zone Right Coordinate: (-0.9, 206) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15.000006, 233.5) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft

Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft
Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 196.8) ft
Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (14.476305, 196.8) ft
Max. Pullout Force: 3,930 lbf
Available Length: 1.1236954 ft
Required Length: 1.1236954 ft
Pullout Force: 362.58309 lbf
Pullout Force per Length: 322.67027 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	235.25 ft
	15.595 ft	235.25 ft
	15.6 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft

Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft
Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 7	Gravel Borrow	32,35,38,36,37	26.85 ft²
Region	ESU 1B Medium Dense to Very Dense Coarse-	12,39,40,41,36,38,13	241.79

8	Grained Fill		ft²
Region 9	Forward Compatible Wall	48,47,49,50	35.36 ft²
Region 10	Common Borrow	39,56,51,36,41,40	75.79 ft²
Region 11	Lightweight EPS	46,54,49,42,52	58.52 ft²
Region 12	Forward Compatible Wall	46,45,53,54	12 ft²
Region 13		50,43,48	5.382 ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15	Forward Compatible Wall	50,49,54,53	65.44 ft²
Region 16	Lightweight EPS	44,42,49,47,33,51,56,55	171.02 ft²
Region 17	Common Borrow	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 8054 of 14196 converged

Current Slip Surface

Slip Surface: 1,484
Factor of Safety: 1.4
Volume: 1,462.0716 ft³
Weight: 154,233.62 lbf
Resisting Moment: 7,320,603.8 lbf·ft
Activating Moment: 5,055,919.6 lbf·ft
Resisting Force: 92,613.876 lbf
Activating Force: 63,988.454 lbf
Slip Rank: 1 of 14,196 slip surfaces
Exit: (-36.305373, 192.35238) ft
Entry: (47.401178, 233.53666) ft
Radius: 68.222101 ft
Center: (-16.430449, 257.61525) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-35.25403 ft	192.05054 ft	-565.9334 psf	113.10941 psf	76.293258 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 2	-33.151343 ft	191.48288 ft	-500.5295 psf	310.78634 psf	209.62803 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 3	-30.816667 ft	190.94016 ft	-433.37397 psf	457.09113 psf	308.31186 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-28.25 ft	190.43746 ft	-365.40816 psf	556.14565 psf	375.12498 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-25.683333 ft	190.03595 ft	-303.75642 psf	625.9387 psf	422.20099 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-22.75 ft	189.70669 ft	-241.38464 psf	749.88352 psf	505.80282 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-19.7 ft	189.48596 ft	-184.12136 psf	875.19474 psf	590.3263 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-17.05 ft	189.40742 ft	-141.43454 psf	932.31077 psf	628.85156 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 9	-14.55 ft	189.43054 ft	-107.23012 psf	969.66752 psf	654.049 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 10	-12.05 ft	189.54545 ft	-78.753687 psf	991.05018 psf	668.47179 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-9.325 ft	189.78039 ft	-54.55872 psf	1,056.7024 psf	712.75476 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-6.375 ft	190.15475 ft	-35.855228 psf	1,147.9819 psf	774.32357 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-4.5 ft	190.44566 ft	-27.272441 psf	1,180.867 psf	796.50482 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.1014612 ft	190.71565 ft	-23.825247 psf	1,107.8996 psf	747.2877 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.5014612 ft	191.04949 ft	-21.276599 psf	1,040.3427 psf	701.72004 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.3 ft	191.48799 ft	-22.314664 psf	3,516.4534 psf	2,371.8778 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	2.65 ft	192.12665 ft	-27.827495 psf	3,323.6121 psf	2,241.8047 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	4.95 ft	192.8413 ft	-38.812424 psf	3,134.5334 psf	2,114.2695 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	7.1 ft	193.5884 ft	-54.014163 psf	4,591.4951 psf	3,097.0025 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 20	9.6 ft	194.57529 ft	-79.064374 psf	4,696.2504 psf	3,167.6609 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 21	11.4 ft	195.32871 ft	-99.775224 psf	4,510.9223 psf	3,042.6555 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	12.590503 ft	195.88138 ft	-118.99826 psf	4,364.9039 psf	2,944.1649 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	13.790503 ft	196.45293 ft	-140.00207 psf	4,239.9512 psf	3,312.6129 psf	0 psf	0 psf	Gravel Borrow
Slice 24	14.8475 ft	196.99151 ft	-160.69619 psf	2,708.0686 psf	2,115.7751 psf	0 psf	0 psf	Gravel Borrow
Slice 25	15.5975 ft	197.3785 ft	-175.6814 psf	2,554.7746 psf	1,996.0087 psf	0 psf	0 psf	Gravel Borrow
Slice 26	16.3825 ft	197.80916 ft	-192.96346 psf	2,405.9519 psf	1,879.7357 psf	0 psf	0 psf	Gravel Borrow
Slice 27	18.90125 ft	199.29025 ft	-246.41775 psf	2,110.2152 psf	1,423.3581 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 28	22.37375 ft	201.54359 ft	-328.2141 psf	1,945.7394 psf	1,312.4178 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 29	25.305 ft	203.66968 ft	-403.289 psf	1,793.7952 psf	1,209.9302 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 30	27.6375 ft	205.55711 ft	-466.04705 psf	1,661.2214 psf	1,120.508 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 31	29.0875 ft	206.79994 ft	-509.39803 psf	1,575.8616 psf	1,062.9321 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 32	29.45 ft	207.1253 ft	-521.14992 psf	1,553.7112 psf	1,047.9914 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	29.51 ft	207.17985 ft	-523.13822 psf	1,550.0368 psf	1,045.513 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	30.51 ft	208.12801 ft	-558.58807 psf	1,486.2252 psf	1,002.4716 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	31.865 ft	209.43291 ft	-607.87832 psf	1,400.5063 psf	944.65344 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	33.4475 ft	211.10441 ft	-672.98058 psf	1,292.1864 psf	871.59075 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	35.8825 ft	213.86586 ft	-784.21021 psf	1,120.174 psf	755.5669 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	38.05 ft	216.58304 ft	-899.38743 psf	958.6536 psf	646.62002 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 39	40.047044 ft	219.39146 ft	-1,024.5344 psf	929.63534 psf	627.04695 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 40	42.141133 ft	222.69471 ft	-1,178.124 psf	693.50493 psf	467.77498 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 41	44.094089 ft	226.196 ft	-1,347.6122 psf	436.56231 psf	379.49783 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 42	46.200589 ft	230.73888 ft	-1,578.2438 psf	197.43972 psf	171.63173 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

1B.2 Compound - Static FC Wall (M-P)

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File Information

File Version: 11.01
Created By: Jon Cracolici
Last Edited By: Bo Zhang
Revision Number: 314
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Tool Version: 11.1.1.22700
File Name: Wall 05.85L-B Sta 2+60_FC Wall (lightweight fill).gsz
Directory: P:\0\0180366\01\Analysis\Wall 05.85L-B\22-01-13\
Last Solved Date: 01/12/2022
Last Solved Time: 10:47:00 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.2 Compound - Static FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced

Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °

Pore Water Pressure
Piezometric Line: 1

Common Borrow

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Row 1 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 2 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 3 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 4 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 5 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.6 °
Surface Area Factor: 2

Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 6 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 7 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 8 (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.1 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Row 9+ (2 strips)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 2.7 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 3,930 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 3,930 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-40, 191.94781) ft
Left-Zone Right Coordinate: (-0.9, 206) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (15.000006, 233.5) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)
Lock to Ground Surface: Yes

Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft
Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 196.8) ft
Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (14.476305, 196.8) ft
Max. Pullout Force: 3,930 lbf
Available Length: 1.1236954 ft
Required Length: 1.1236954 ft
Pullout Force: 362.58309 lbf
Pullout Force per Length: 322.67027 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 250 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	235.25 ft
	15.595 ft	235.25 ft
	15.6 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft

Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft
Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region	Gravel Borrow	32,35,38,36,37	26.85

7			ft²
Region 8	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill	12,39,40,41,36,38,13	241.79 ft²
Region 9	Forward Compatible Wall	48,47,49,50	35.36 ft²
Region 10	Common Borrow	39,56,51,36,41,40	75.79 ft²
Region 11	Lightweight EPS	46,54,49,42,52	58.52 ft²
Region 12	Forward Compatible Wall	46,45,53,54	12 ft²
Region 13		50,43,48	5.382 ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15	Forward Compatible Wall	50,49,54,53	65.44 ft²
Region 16	Lightweight EPS	44,42,49,47,33,51,56,55	171.02 ft²
Region 17	Common Borrow	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 11059 of 14196 converged

Current Slip Surface

Slip Surface: 1,484
Factor of Safety: 1.5
Volume: 1,462.0716 ft³
Weight: 154,233.62 lbf
Resisting Moment: 7,334,172.3 lbf·ft
Activating Moment: 5,055,919.6 lbf·ft
Resisting Force: 92,660.073 lbf
Activating Force: 63,915.255 lbf
Slip Rank: 1 of 14,196 slip surfaces
Exit: (-36.305373, 192.35238) ft
Entry: (47.401178, 233.53666) ft
Radius: 68.222101 ft
Center: (-16.430449, 257.61525) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-35.25403 ft	192.05054 ft	-565.9334 psf	67.826152 psf	45.749317 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
								ESU 2B Medium

Slice 2	-33.151343 ft	191.48288 ft	-500.5295 psf	206.10201 psf	139.01756 psf	0 psf	0 psf	Dense Sand/Gravel
Slice 3	-30.816667 ft	190.94016 ft	-433.37397 psf	338.80054 psf	228.52385 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 4	-28.25 ft	190.43746 ft	-365.40816 psf	460.45058 psf	310.57784 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 5	-25.683333 ft	190.03595 ft	-303.75642 psf	570.4107 psf	384.74688 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 6	-22.75 ft	189.70669 ft	-241.38464 psf	741.18937 psf	499.93854 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 7	-19.7 ft	189.48596 ft	-184.12136 psf	921.58808 psf	621.61901 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 8	-17.05 ft	189.40742 ft	-141.43454 psf	1,026.7015 psf	692.51893 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 9	-14.55 ft	189.43054 ft	-107.23012 psf	1,099.4904 psf	741.61564 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 10	-12.05 ft	189.54545 ft	-78.753687 psf	1,143.5521 psf	771.33566 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 11	-9.325 ft	189.78039 ft	-54.55872 psf	1,220.1229 psf	822.9833 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 12	-6.375 ft	190.15475 ft	-35.855228 psf	1,308.3939 psf	882.52284 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 13	-4.5 ft	190.44566 ft	-27.272441 psf	1,334.0365 psf	899.81896 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 14	-3.1014612 ft	190.71565 ft	-23.825247 psf	1,243.973 psf	839.07041 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 15	-1.5014612 ft	191.04949 ft	-21.276599 psf	1,158.0885 psf	781.14057 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 16	0.3 ft	191.48799 ft	-22.314664 psf	3,682.8296 psf	2,484.0999 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 17	2.65 ft	192.12665 ft	-27.827495 psf	3,442.8598 psf	2,322.2383 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 18	4.95 ft	192.8413 ft	-38.812424 psf	3,200.9791 psf	2,159.0876 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 19	7.1 ft	193.5884 ft	-54.014163 psf	4,627.9851 psf	3,121.6154 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 20	9.6 ft	194.57529 ft	-79.064374 psf	4,667.3048 psf	3,148.1368 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 21	11.4 ft	195.32871 ft	-99.775224 psf	4,441.1593 psf	2,995.5998 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 22	12.590503 ft	195.88138 ft	-118.99826 psf	4,266.3091 psf	2,877.6618 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 23	13.790503 ft	196.45293 ft	-140.00207 psf	4,148.8121 psf	3,241.4072 psf	0 psf	0 psf	Gravel Borrow
Slice 24	14.8475 ft	196.99151 ft	-160.69619 psf	2,590.389 psf	2,023.8337 psf	0 psf	0 psf	Gravel Borrow
Slice 25	15.5975 ft	197.3785 ft	-175.6814 psf	2,423.8101 psf	1,893.688 psf	0 psf	0 psf	Gravel Borrow
Slice 26	16.3825 ft	197.80916 ft	-192.96346 psf	2,264.4011 psf	1,769.1441 psf	0 psf	0 psf	Gravel Borrow
Slice 27	18.90125 ft	199.29025 ft	-246.41775 psf	1,937.8055 psf	1,307.0663 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 28	22.37375 ft	201.54359 ft	-328.2141 psf	1,767.2582 psf	1,192.0307 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 29	25.305 ft	203.66968 ft	-403.289 psf	1,628.0743 psf	1,098.15 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 30	27.6375 ft	205.55711 ft	-466.04705 psf	1,517.2893 psf	1,023.4245 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 31	29.0875 ft	206.79994 ft	-509.39803 psf	1,449.6216 psf	977.78214 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 32	29.45 ft	207.1253 ft	-521.14992 psf	1,432.4616 psf	966.20754 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 33	29.51 ft	207.17985 ft	-523.13822 psf	1,429.6368 psf	964.30217 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 34	30.51 ft	208.12801 ft	-558.58807 psf	1,381.0467 psf	931.52779 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 35	31.865 ft	209.43291 ft	-607.87832 psf	1,317.2418 psf	888.49082 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 36	33.4475 ft	211.10441 ft	-672.98058 psf	1,237.5934 psf	834.7673 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 37	35.8825 ft	213.86586 ft	-784.21021 psf	1,112.2391 psf	750.21477 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 38	38.05 ft	216.58304 ft	-899.38743 psf	992.60833 psf	669.52277 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

Slice 39	40.047044 ft	219.39146 ft	-1,024.5344 psf	1,023.7818 psf	690.54958 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 40	42.141133 ft	222.69471 ft	-1,178.124 psf	813.62382 psf	548.7962 psf	0 psf	0 psf	ESU 2B Medium Dense Sand/Gravel
Slice 41	44.094089 ft	226.196 ft	-1,347.6122 psf	525.31819 psf	456.65213 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill
Slice 42	46.200589 ft	230.73888 ft	-1,578.2438 psf	257.56458 psf	223.89748 psf	0 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill

1B.3 Compound - Pseudo-Static FC Wall (Spencer)

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File Information

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Last Solved Date: 01/12/2022
Last Solved Time: 10:48:02 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.3 Compound - Pseudo-Static FC Wall (Spencer)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Spencer
Settings
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft

Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
    Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
    Piezometric Line: 1

Reinforcements

Row 1 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.9 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 8 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 9+ (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2

Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-46, 191.32629) ft
Left-Zone Right Coordinate: (-0.9, 206) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (20, 233.5) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.196

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)(EQ)

Lock to Ground Surface: Yes
Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft
Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf

Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No
Outside Point: (-0.9, 196.8) ft
Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (15.031415, 196.8) ft
Max. Pullout Force: 5,240 lbf
Available Length: 0.56858467 ft
Required Length: 0.56858467 ft
Pullout Force: 224.94028 lbf
Pullout Force per Length: 395.6144 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft
Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft

Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft
Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²
Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region	Gravel Borrow	32,35,38,36,37	26.85

7			ft²
Region 8	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	12,39,40,41,36,38,13	241.79 ft²
Region 9	Forward Compatible Wall	48,47,49,50	35.36 ft²
Region 10	Common Borrow (Apparent Cohesion)	39,56,51,36,41,40	75.79 ft²
Region 11	Lightweight EPS	46,54,49,42,52	58.52 ft²
Region 12	Forward Compatible Wall	46,45,53,54	12 ft²
Region 13		50,43,48	5.382 ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15	Forward Compatible Wall	50,49,54,53	65.44 ft²
Region 16	Lightweight EPS	44,42,49,47,33,51,56,55	171.02 ft²
Region 17	Common Borrow (Apparent Cohesion)	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 6871 of 14196 converged

Current Slip Surface

Slip Surface: 2,637
Factor of Safety: 1.3
Volume: 1,587.1579 ft³
Weight: 169,208.24 lbf
Resisting Moment: 10,182,394 lbf·ft
Activating Moment: 7,860,517.9 lbf·ft
Resisting Force: 112,963.45 lbf
Activating Force: 87,195.976 lbf
Slip Rank: 1 of 14,196 slip surfaces
Exit: (-37.644692, 192.19178) ft
Entry: (53.600696, 233.63131) ft
Radius: 80.16144 ft
Center: (-17.895571, 269.88238) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	-37.122346 ft	192.06273 ft	-593.33414 psf	534.5441 psf	360.55455 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent

								Cohesion)
Slice 2	-34.35 ft	191.46157 ft	-516.29165 psf	746.53063 psf	503.54127 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 3	-30.816667 ft	190.77985 ft	-423.37067 psf	907.46284 psf	612.09141 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 4	-28.25 ft	190.40303 ft	-363.25958 psf	933.7448 psf	629.81882 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 5	-25.683333 ft	190.11055 ft	-308.41141 psf	938.99055 psf	633.35713 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 6	-22.75 ft	189.88514 ft	-252.51981 psf	1,005.0567 psf	677.91933 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 7	-19.7 ft	189.75349 ft	-200.81527 psf	1,077.7369 psf	726.94271 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 8	-16.425 ft	189.75637 ft	-154.29768 psf	1,092.5161 psf	736.91143 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 9	-12.675 ft	189.91319 ft	-110.61245 psf	1,087.4766 psf	733.51225 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 10	-9.325 ft	190.19423 ft	-80.382447 psf	1,123.5112 psf	757.81786 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 11	-6.375 ft	190.56711 ft	-61.586791 psf	1,187.0156 psf	800.65213 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 12	-4.5 ft	190.84916 ft	-52.450883 psf	1,205.2242 psf	812.93395 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent

								Cohesion)
Slice 13	-2.5 ft	191.23014 ft	-47.140556 psf	1,090.8043 psf	735.75682 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	-0.52880405 ft	191.6257 ft	-43.019319 psf	3,490.4399 psf	2,354.3314 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	0.67119595 ft	191.90542 ft	-42.9386 psf	3,370.4213 psf	2,273.3778 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	2.65 ft	192.40774 ft	-45.36732 psf	3,190.9617 psf	2,152.3308 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	4.95 ft	193.05467 ft	-52.126937 psf	2,991.2586 psf	2,017.6294 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	7.1 ft	193.72485 ft	-62.528581 psf	4,334.7594 psf	2,923.8321 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	9.6 ft	194.60091 ft	-80.663336 psf	4,176.0116 psf	2,816.7554 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 20	11.4 ft	195.26655 ft	-95.896548 psf	3,997.8667 psf	2,696.5951 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 21	12.804178 ft	195.84217 ft	-113.94113 psf	3,835.1737 psf	2,586.8573 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 22	14.004178 ft	196.34156 ft	-130.44262 psf	3,800.4732 psf	2,969.2551 psf	0 psf	0 psf	Gravel Borrow
Slice 23	14.85 ft	196.7188 ft	-143.64865 psf	2,351.2309 psf	1,836.9829 psf	0 psf	0 psf	Gravel Borrow
Slice 24	16.3825 ft	197.42466 ft	-168.97102 psf	2,211.0153 psf	1,727.4345 psf	0 psf	0 psf	Gravel Borrow
Slice		198.69228	-209.10425	1,926.6866	1,299.5665			ESU 2B Medium Dense

25	18.90125 ft	ft	psf	psf	psf	200 psf	0 psf	Sand/Gravel (Apparent Cohesion)
Slice 26	22.37375 ft	200.59887 ft	-269.26329 psf	1,787.3718 psf	1,205.5975 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 27	25.305 ft	202.37272 ft	-322.35872 psf	1,663.7934 psf	1,122.2428 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 28	27.6375 ft	203.92266 ft	-364.05701 psf	1,559.6404 psf	1,051.9907 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 29	29.0875 ft	204.93395 ft	-392.96 psf	1,493.7635 psf	1,007.5562 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 30	29.45 ft	205.19661 ft	-400.79929 psf	1,476.8947 psf	996.17806 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 31	29.51 ft	205.24054 ft	-402.12529 psf	1,474.1117 psf	994.30088 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 32	30.51 ft	205.998 ft	-425.67563 psf	1,426.3467 psf	962.08303 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 33	31.865 ft	207.03713 ft	-458.3816 psf	1,362.4705 psf	918.99795 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 34	33.4475 ft	208.34189 ft	-500.59964 psf	1,283.7822 psf	865.92203 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 35	35.8825 ft	210.4595 ft	-571.65286 psf	1,161.0094 psf	783.11072 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 2B Medium Dense

Slice 36	38.05 ft	212.48735 ft	-643.81636 psf	1,048.1926 psf	707.01482 psf	200 psf	0 psf	Sand/Gravel (Apparent Cohesion)
Slice 37	40.5 ft	215.00966 ft	-739.74701 psf	1,026.3518 psf	692.28303 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 38	43.5 ft	218.3946 ft	-875.70871 psf	778.24147 psf	524.9305 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 39	46.591017 ft	222.34137 ft	-1,044.4447 psf	525.32743 psf	354.33782 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 40	49.77305 ft	227.01075 ft	-1,255.9888 psf	271.63023 psf	183.2169 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 41	52.482381 ft	231.57666 ft	-1,472.9344 psf	86.359899 psf	75.071515 psf	100 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

1B.4 Compound - Pseudo-Static FC Wall (M-P)

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File Information

File Version: 11.01
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Last Edited By: Bo Zhang
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Last Solved Date: 01/12/2022
Last Solved Time: 10:48:48 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

1B.4 Compound - Pseudo-Static FC Wall (M-P)

Description: With Forward Compatible Wall
Kind: SLOPE/W
Analysis Type: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
- Apply Phreatic Correction: No
- Use Staged Rapid Drawdown: No
- Critical Slip Surface Source from: (none)
- Unit Weight of Water: 62.4 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit
- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: No
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced

Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

ESU 4B Dense to Very Dense Sand/Gravel

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 43 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Gravel Borrow

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 38 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 0 psf
Effective Friction Angle: 42 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 130 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 41 °
Phi-B: 0 °

Pore Water Pressure
Piezometric Line: 1

ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 115 pcf
Effective Cohesion: 200 psf
Effective Friction Angle: 34 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Forward Compatible Wall

Material Model: High Strength
Unit Weight: 130 pcf
Pore Water Pressure
Piezometric Line: 1

Common Borrow (Apparent Cohesion)

Material Model: Mohr-Coulomb
Unit Weight: 120 pcf
Effective Cohesion: 50 psf
Effective Friction Angle: 32 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Lightweight EPS

Material Model: Mohr-Coulomb
Unit Weight: 5 pcf
Effective Cohesion: 100 psf
Effective Friction Angle: 0 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Reinforcements

Row 1 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No

Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 2 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 8.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 3 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 7.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 4 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.8 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 5 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 6.2 °
Surface Area Factor: 2

Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 6 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 5.5 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 7 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.9 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 8 (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 4.2 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Row 9+ (2 strips)(EQ)

Type: Geosynthetic
Interface Adhesion: 0 psf
Interface Shear Angle: 3.6 °
Surface Area Factor: 2
Pullout Resistance Reduction Factor: 1
Tensile Capacity: 5,240 lbf
Tensile Capacity Reduction Factor: 1
F of S Dependent: No
Force Distribution: Distributed
Face Anchorage: Yes
Factored Tensile Capacity: 5,240 lbf/ft

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (-46, 191.32629) ft
Left-Zone Right Coordinate: (-0.9, 206) ft
Left-Zone Increment: 25
Right Type: Range
Right-Zone Left Coordinate: (20, 233.5) ft
Right-Zone Right Coordinate: (60, 233.74338) ft
Right-Zone Increment: 25
Radius Increments: 20

Slip Surface Limits

Left Coordinate: (-80, 186.2) ft
Right Coordinate: (80, 234.2) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	-48.3 ft	180 ft
Coordinate 2	-4.1 ft	190.1 ft
Coordinate 3	11.7 ft	193.8 ft
Coordinate 4	17.165 ft	194.87 ft
Coordinate 5	24.11 ft	196.755 ft
Coordinate 6	29.52 ft	198.8 ft
Coordinate 7	32.23 ft	199.83 ft
Coordinate 8	60.885 ft	211.35 ft
Coordinate 9	70.775 ft	215.12 ft
Coordinate 10	74.125 ft	216.15 ft
Coordinate 11	80 ft	217.365 ft

Seismic Coefficients

Horz Seismic Coef.: 0.196

Reinforcement Lines

Reinforcement Line 1

Reinforcement: Row 1 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 218.4) ft
Inside Point: (15.6, 218.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 2

Reinforcement: Row 3 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 213.6) ft
Inside Point: (15.6, 213.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 3

Reinforcement: Row 2 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 216) ft
Inside Point: (15.6, 216) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft

Governing Component: (none)

Reinforcement Line 4

Reinforcement: Row 7 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 204) ft
Inside Point: (15.6, 204) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 5

Reinforcement: Row 6 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 206.4) ft
Inside Point: (15.6, 206.4) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 6

Reinforcement: Row 5 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 208.8) ft
Inside Point: (15.6, 208.8) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 7

Reinforcement: Row 4 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 211.2) ft

Inside Point: (15.6, 211.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 8

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No
Outside Point: (-0.9, 196.8) ft
Inside Point: (15.6, 196.8) ft
Length: 16.5 ft
Orientation: 0 °
Slip Surface Intersection: (15.031415, 196.8) ft
Max. Pullout Force: 5,240 lbf
Available Length: 0.56858467 ft
Required Length: 0.56858467 ft
Pullout Force: 224.94028 lbf
Pullout Force per Length: 395.6144 lbf/ft
Governing Component: Pullout Resistance

Reinforcement Line 9

Reinforcement: Row 9+ (2 strips)(EQ)
Lock to Ground Surface: No
Outside Point: (-0.9, 199.2) ft
Inside Point: (15.6, 199.2) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft
Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Reinforcement Line 10

Reinforcement: Row 8 (2 strips)(EQ)
Lock to Ground Surface: Yes
Outside Point: (-0.9, 201.6) ft
Inside Point: (15.6, 201.6) ft
Length: 16.5 ft
Orientation: 0 °
Max. Pullout Force: 0 lbf
Available Length: 0 ft

Required Length: 0 ft
Pullout Force: 0 lbf
Pullout Force per Length: 0 lbf/ft
Governing Component: (none)

Surcharge Loads

Surcharge Load 1

Surcharge (Unit Weight): 125 pcf
Direction: Vertical

Coordinates

	X	Y
	8.1 ft	234.5 ft
	45 ft	234.5 ft
	58.1 ft	234.7 ft
	80 ft	235.2 ft

Geometry

Name: 1. Compound Stability

Settings

View: 2D
Element Thickness: 1 ft

Points

	X	Y
Point 1	80 ft	199.4 ft
Point 2	58 ft	196.6 ft
Point 3	37.6 ft	191.9 ft
Point 4	42.1 ft	180 ft
Point 5	80 ft	180 ft
Point 6	80 ft	226 ft
Point 7	58 ft	225.3 ft
Point 8	29.8 ft	195 ft
Point 9	11.7 ft	193.8 ft
Point 10	-48.3 ft	180 ft
Point 11	80 ft	234.2 ft
Point 12	58.1 ft	233.7 ft
Point 13	26.5 ft	214.1 ft
Point 14	-10.8 ft	197 ft
Point 15	-18.3 ft	195.3 ft
Point 16	-21.1 ft	194.7 ft
Point 17	-24.4 ft	193.6 ft
Point 18	-32.1 ft	193.1 ft

Point 19	-36.6 ft	192.3 ft
Point 20	-61.7 ft	189.7 ft
Point 21	-65.4 ft	189.3 ft
Point 22	-73.2 ft	188 ft
Point 23	-80 ft	186.2 ft
Point 24	-80 ft	180 ft
Point 25	-4.1 ft	190.1 ft
Point 26	32 ft	197.4 ft
Point 27	-0.9 ft	219.4 ft
Point 28	-0.9 ft	196.3 ft
Point 29	-4.9 ft	199.8 ft
Point 30	-0.9 ft	199.8 ft
Point 31	-0.9 ft	199.4 ft
Point 32	15.6 ft	196.3 ft
Point 33	15.6 ft	219.4 ft
Point 34	11.1 ft	196.3 ft
Point 35	17.1 ft	196.3 ft
Point 36	17.1 ft	214.2 ft
Point 37	15.6 ft	214.2 ft
Point 38	17.1 ft	208.4 ft
Point 39	45 ft	233.5 ft
Point 40	37.1 ft	228.2 ft
Point 41	29.4 ft	222.3 ft
Point 42	29.5 ft	233.5 ft
Point 43	1.5 ft	219.4 ft
Point 44	31.5 ft	233.5 ft
Point 45	6.1 ft	233.5 ft
Point 46	14.1 ft	233.5 ft
Point 47	14.1 ft	219.4 ft
Point 48	6.1 ft	219.4 ft
Point 49	14.1 ft	225.9 ft
Point 50	6.1 ft	221.74 ft
Point 51	17.1 ft	219.4 ft
Point 52	28.775 ft	233.5 ft
Point 53	6.1 ft	232 ft
Point 54	14.1 ft	232 ft
Point 55	39 ft	233.5 ft
Point 56	39 ft	230.5 ft

Regions

	Material	Points	Area
Region 1	ESU 5B Very Stiff to Hard Silt and Clay/Dense to Very Dense Silt	1,2,3,4,5	659.92 ft²
Region 2	ESU 4B Dense to Very Dense Sand/Gravel	1,6,7,26,8,9,25,10,4,3,2	1,867.8 ft²
Region 3	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	14,29,30,31	7.58 ft²
Region 4	Gravel Borrow	27,30,31,28,34,32,37,33,47,48,43	381.15 ft²

Region 5	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	7,6,11,12,13,38,35,32,34,25,9,8,26	856.44 ft²
Region 6	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)	14,15,16,17,18,19,20,21,22,23,24,10,25,34,28,31	748.7 ft²
Region 7	Gravel Borrow	32,35,38,36,37	26.85 ft²
Region 8	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)	12,39,40,41,36,38,13	241.79 ft²
Region 9	Forward Compatible Wall	48,47,49,50	35.36 ft²
Region 10	Common Borrow (Apparent Cohesion)	39,56,51,36,41,40	75.79 ft²
Region 11	Lightweight EPS	46,54,49,42,52	58.52 ft²
Region 12	Forward Compatible Wall	46,45,53,54	12 ft²
Region 13		50,43,48	5.382 ft²
Region 14	Gravel Borrow	33,37,36,51	7.8 ft²
Region 15	Forward Compatible Wall	50,49,54,53	65.44 ft²
Region 16	Lightweight EPS	44,42,49,47,33,51,56,55	171.02 ft²
Region 17	Common Borrow (Apparent Cohesion)	39,55,56	9 ft²

Slip Results

Slip Surfaces Analysed: 8578 of 14196 converged

Current Slip Surface

Slip Surface: 2,637
Factor of Safety: 1.3
Volume: 1,587.1579 ft³
Weight: 169,208.24 lbf
Resisting Moment: 10,167,731 lbf·ft
Activating Moment: 7,860,517.9 lbf·ft
Resisting Force: 112,873.54 lbf
Activating Force: 87,258.916 lbf
Slip Rank: 1 of 14,196 slip surfaces
Exit: (-37.644692, 192.19178) ft
Entry: (53.600696, 233.63131) ft
Radius: 80.16144 ft
Center: (-17.895571, 269.88238) ft

Slip Slices

	X	Y	PWP	Base Normal	Frictional	Cohesive	Suction	Base Material

				Stress	Strength	Strength	Strength	
Slice 1	-37.122346 ft	192.06273 ft	-593.33414 psf	86.237165 psf	58.167702 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 2	-34.35 ft	191.46157 ft	-516.29165 psf	322.38595 psf	217.45207 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 3	-30.816667 ft	190.77985 ft	-423.37067 psf	602.25906 psf	406.22887 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 4	-28.25 ft	190.40303 ft	-363.25958 psf	759.45738 psf	512.26047 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 5	-25.683333 ft	190.11055 ft	-308.41141 psf	893.78875 psf	602.86812 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 6	-22.75 ft	189.88514 ft	-252.51981 psf	1,077.9365 psf	727.07738 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 7	-19.7 ft	189.75349 ft	-200.81527 psf	1,257.5376 psf	848.21979 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 8	-16.425 ft	189.75637 ft	-154.29768 psf	1,366.8103 psf	921.92517 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 9	-12.675 ft	189.91319 ft	-110.61245 psf	1,425.4135 psf	961.45358 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 10	-9.325 ft	190.19423 ft	-80.382447 psf	1,475.5869 psf	995.29595 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 11	-6.375 ft	190.56711 ft	-61.586791 psf	1,523.0074 psf	1,027.2814 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel

								(Apparent Cohesion)
Slice 12	-4.5 ft	190.84916 ft	-52.450883 psf	1,520.3098 psf	1,025.4619 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 13	-2.5 ft	191.23014 ft	-47.140556 psf	1,368.9859 psf	923.39268 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 14	-0.52880405 ft	191.6257 ft	-43.019319 psf	3,747.8391 psf	2,527.9494 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 15	0.67119595 ft	191.90542 ft	-42.9386 psf	3,596.145 psf	2,425.6305 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 16	2.65 ft	192.40774 ft	-45.36732 psf	3,358.7922 psf	2,265.534 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 17	4.95 ft	193.05467 ft	-52.126937 psf	3,086.0908 psf	2,081.5946 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 18	7.1 ft	193.72485 ft	-62.528581 psf	4,349.8942 psf	2,934.0407 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 19	9.6 ft	194.60091 ft	-80.663336 psf	4,110.6346 psf	2,772.6581 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 20	11.4 ft	195.26655 ft	-95.896548 psf	3,883.4031 psf	2,619.3885 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 21	12.804178 ft	195.84217 ft	-113.94113 psf	3,684.3233 psf	2,485.1075 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 22	14.004178 ft	196.34156 ft	-130.44262 psf	3,648.5895 psf	2,850.5905 psf	0 psf	0 psf	Gravel Borrow
Slice		196.7188	-143.64865	2,188.9752	1,710.2149			

23	14.85 ft	ft	psf	psf	psf	0 psf	0 psf	Gravel Borrow
Slice 24	16.3825 ft	197.42466 ft	-168.97102 psf	2,023.2114 psf	1,580.706 psf	0 psf	0 psf	Gravel Borrow
Slice 25	18.90125 ft	198.69228 ft	-209.10425 psf	1,716.7171 psf	1,157.9403 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 26	22.37375 ft	200.59887 ft	-269.26329 psf	1,562.852 psf	1,054.157 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 27	25.305 ft	202.37272 ft	-322.35872 psf	1,446.6343 psf	975.76717 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 28	27.6375 ft	203.92266 ft	-364.05701 psf	1,360.3076 psf	917.53905 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 29	29.0875 ft	204.93395 ft	-392.96 psf	1,309.6118 psf	883.3443 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 30	29.45 ft	205.19661 ft	-400.79929 psf	1,297.0923 psf	874.89979 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 31	29.51 ft	205.24054 ft	-402.12529 psf	1,295.0522 psf	873.52371 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 32	30.51 ft	205.998 ft	-425.67563 psf	1,260.7102 psf	850.35978 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 33	31.865 ft	207.03713 ft	-458.3816 psf	1,216.3148 psf	820.41466 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 34	33.4475 ft	208.34189 ft	-500.59964 psf	1,163.6171 psf	784.86968 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
								ESU 2B Medium

Slice 35	35.8825 ft	210.4595 ft	-571.65286 psf	1,084.4462 psf	731.46817 psf	200 psf	0 psf	Dense Sand/Gravel (Apparent Cohesion)
Slice 36	38.05 ft	212.48735 ft	-643.81636 psf	1,013.2459 psf	683.44296 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 37	40.5 ft	215.00966 ft	-739.74701 psf	1,064.0407 psf	717.70449 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 38	43.5 ft	218.3946 ft	-875.70871 psf	863.85957 psf	582.68064 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 39	46.591017 ft	222.34137 ft	-1,044.4447 psf	632.30487 psf	426.49502 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 40	49.77305 ft	227.01075 ft	-1,255.9888 psf	349.2937 psf	235.60158 psf	200 psf	0 psf	ESU 2B Medium Dense Sand/Gravel (Apparent Cohesion)
Slice 41	52.482381 ft	231.57666 ft	-1,472.9344 psf	107.65152 psf	93.58004 psf	100 psf	0 psf	ESU 1B Medium Dense to Very Dense Coarse-Grained Fill (Apparent Cohesion)